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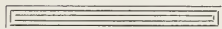


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CHICAGO, ILLINOIS



VOLUME V. JANUARY, 1913 NUMBER 1.

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The Armour Engineer

VOLUME V.

JANUARY, 1913

NUMBER 1.

THE NEW SOUTHWEST LAND AND LAKE TUNNEL SYSTEM OF THE CHICAGO WATERWORKS.

BY HENRY W. CLAUSEN, C. E.*

For the purpose of relieving the water shortage in the extreme south and southwest portions of Chicago, as well as to reinforce the supply for Hyde Park and Englewood, the plan for the construction of the Southwest Land and Lake Tunnel System was decided upon by the Department of Public Works during the year 1905.

After careful study it was decided to provide a supply for a daily pumpage of not less than 300,000,000 gallons from three different additional pumping stations. The sizes of the tunnels were figured so that the average velocity of the water should not exceed 2 feet per second.

On account of the operating conditions and quality of water, a site for an intake crib adjacent to the present Hyde Park crib was selected. This crib is about 10,000 feet off shore, due east from 59th street, about six and one-half miles south from the commercial center of the city.

Sites for the three pumping stations were adopted as follows: One in the vicinity of South Chicago; one at 75th street and Western avenue, and one at 104th street and Harvard avenue. The latter point being in the territory of greatest need as to water supply, plans were made with a view of completing that station first, and necessary funds were appropriated by the City Council for starting the work in 1906.

The following alignment was adopted: The new crib was located a short distance south of the Hyde Park crib, from which a 14-foot tunnel was run to a short shaft at the foot of 73rd street; thence west with a 14-foot tunnel to Yates avenue, continuing westwardly with a 12-foot tunnel to State street, and southerly in Yates avenue with a short 9-foot branch, which will in time be extended to South Chicago. A short 9-foot branch was also extended westerly in 73rd street from State street, which in time will be run to the vicinity of 75th street and Western

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avenue. A 9-foot tunnel was run south in State street from 73rd street to 104th street, thence west on 104th street to the Roseland Pumping Station, situated at 104th street and Harvard avenue, adjacent to the Chicago and Western Indiana Railroad. It was later on decided to build a short 9-foot extension from the 12-foot tunnel in Seventy-third street northerly in Oglesby avenue, to provide for a future extension to the new Hyde Park Pumping Station.

Past experience in constructing the Hyde Park water tunnels, which are in this vicinity, indicated that the new tunnels should be built entirely in rock. After some investigations as to the relative merits of the following cross sections the horseshoe cross section was adopted:

Circular section.

Rectangular section, with sides, tops and bottom slightly concaved.

Horseshoe section, with top semi-circular and sides and bottom of approximately double the top radius.

The adopted velocity of 2 feet per second required the equivalent of a 14-foot circular section for 300,000,000 gallons daily flow, a similar 12-foot section for the 200,000,000-gallon flow, and a similar 9-foot section for the 100,000,000-gallon flow.

Borings were made in 1905-1906 to locate bed-rock. A contract was let to the Great Lakes Dredge & Dock Company for two borings in the lake. Borings on land were made by city forces, and later two further borings were made in the lake.

The adopted profile started at —123 feet at the intake crib and rose gradually, approximately following the upper surface of the rock, to an elevation of —90 feet at the station. During construction, when the actual condition of the rock was more definitely ascertained, the profile and alignment were altered as shown in Figs. 1, 2 and 3.

The cross-sections adopted were as shown in Fig. 4. The shafts and tunnels were lined with concrete (mixed in proportion of one part Portland cement, three parts torpedo sand and six parts crushed stone) of the following thicknesses:

10-foot shaft in earth, 14 inches; in rock, 8 inches.

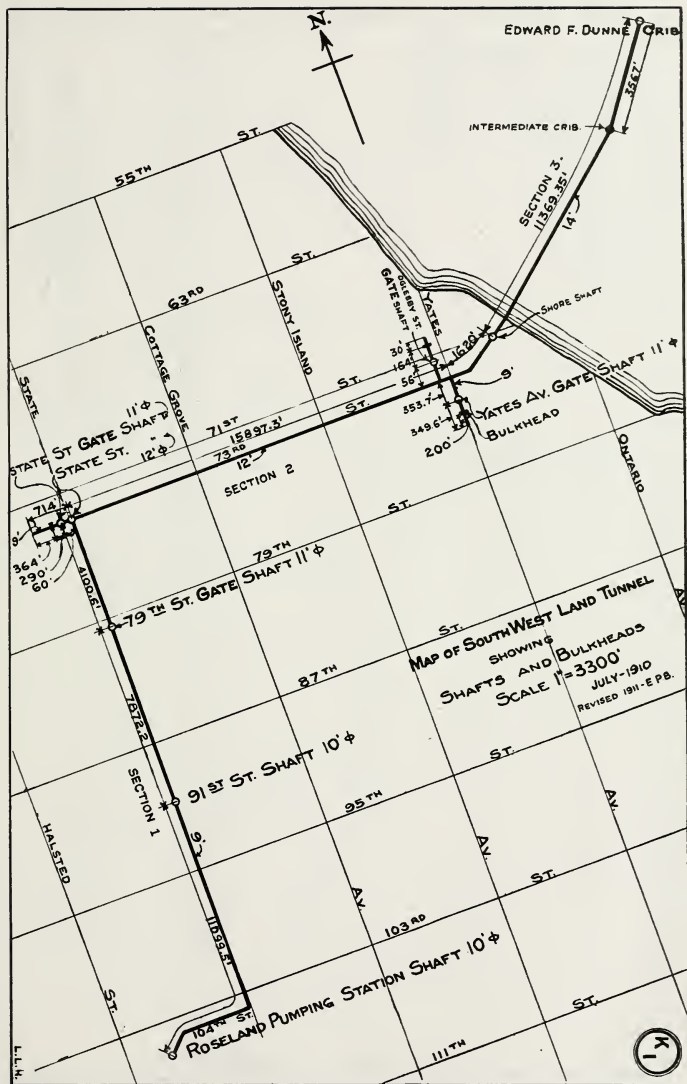
11-foot shaft in earth, 14 inches; in rock, 8 inches.

12-foot shaft in earth, 18 inches; in rock, 10 inches.

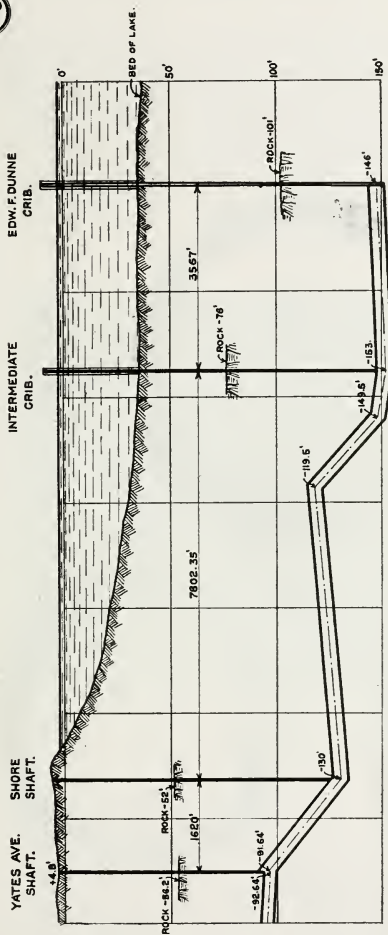
9-foot tunnel in rock, 4 inches plus 3 inches.

12-foot tunnel in rock, 4 inches plus 5 inches.

14-foot tunnel in rock, 12 inches plus 5 inches.



K 3



DIAM. OF TUNNEL FROM E F DUNNE CRIB TO YATES AVE. SHAFT = 141'

CITY OF CHICAGO
DEPARTMENT OF PUBLIC WORKS
BUREAU OF ENGINEERING

SOUTHWEST LAND TUNNEL PROFILE OF SECTION No. 3 (Lake Section)

FILE 3-N.

1911

E.R.G.

Fig. 3.

The added thicknesses were for an exterior layer within which not more than 15 per cent of rock projections were to be permitted. The enforcement of this requirement was found to be complicated, so that on Section 3, or the lake section, a minimum thickness of 12 inches was adopted. The 9-foot tunnel in Oglesby avenue was likewise built with a 10-inch lining.

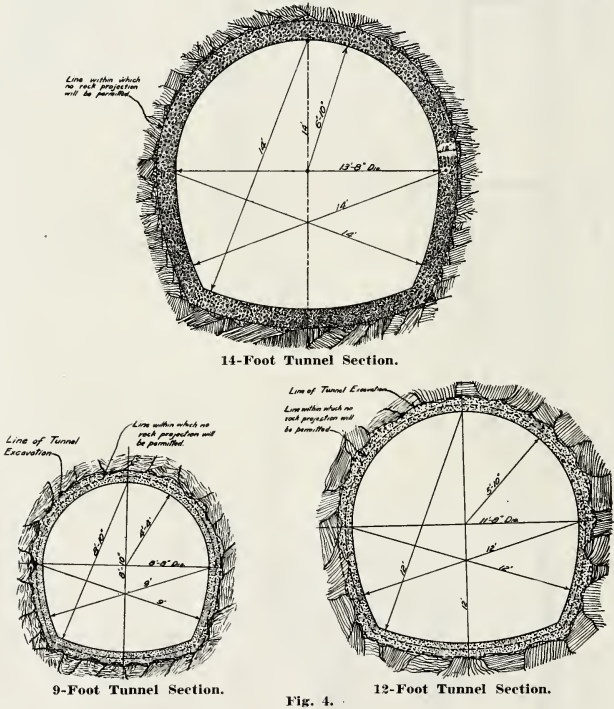


Fig. 4.

It was decided to divide the tunnel work into three major contracts, known as Sections Nos. 1, 2 and 3. By reference to Fig. 1 it will be seen that Section 1 consists of that part of the system from the Roseland Pumping Station to a point about 600 feet south of Seventy-third street, on State street, and is 22,366 feet long. Section 2 is that part of the tunnel from a point on State street about 600 feet south of 73rd street, including the 9-foot

branch in 73rd street west of State street, to a point located in 73rd street, near Railroad avenue. Its total length is 18,877 feet. Section 3 extends from the end of Section 2, at 73rd street and Railroad avenue, to the crib, and is 12,178 feet long.

Ground for Section 1 was broken on April 13, 1906, and the work was completed April 30, 1909, at a cost of \$603,494.

Ground for Section 2 was broken on Sept. 6, 1906, and was completed Oct. 20, 1908, at a cost of \$826,903.

Ground for Section 3 was broken May 9, 1907, and the tunnel was completed and water from the lake turned into the entire



Fig. 5. Southwest Land Tunnel. View at Yates Avenue and 73rd Street Looking West, and Showing an Intersection Between 14-Foot, 12-Foot and 9-Foot Tunnels.

system Dec. 21, 1911. The total cost of this section was \$1,567,955.

The four shafts, one of which was for construction purposes only, on Section 1 were sunk to rock by a common method of mine timbering, using square sets of timbering to hold back the soil. The four permanent shafts of Section 2 were sunk by using a circular sheathing similar to that used in sinking the caissons for foundations of large buildings in the loop district. The temporary, or working, shafts were constructed with square sets of timbering similar to those used in Section 1. The shore shaft and intermediate crib shaft of Section 3 were sunk by using an interlocking steel sheathing. The two shafts at the permanent crib were sunk by lowering a steel shell, 16 feet in diameter, or

2 feet larger than the cast-iron cylinders, to the bed of the lake, and filling same with sand. The cast-iron shafts, in 8-foot sections, were placed inside of the steel shell on the sand, and the sand then removed, allowing the cast-iron cylinders to settle to the desired elevation of -54.03 feet.

The intake crib, called the Edward F. Dunne Crib, rests on the lake bottom at elevation -34 feet, and is built on a foundation of solid timber work, resting on a 12-inch sill course. The base is 24-sided, in a 112-foot circle, and 4 feet 4 inches deep over the



Fig. 6. Southwest Land Tunnel. Approach to Sluice Gate, Showing Venturi Section.

entire area. The interior well is 60 feet in diameter, enclosed in solid timber walls 20 feet high, concrete walls lined with steel inside and out, 14 feet high, and a concrete and masonry wall 7 feet 6 inches high, the steel shell lapping the granite 6 inches. The upper surface of the solid crib wall is at an average elevation of $+15.25$ feet. On this, as a base, two walls were built—a heavy exterior parapet wall of concrete with granite facing blocks 10 feet thick at the base, and a 26-inch brick wall to provide a well house. In the latter wall are seventeen windows, 7 feet by 3 feet 6 inches, and one door, 7 feet by 3 feet 6 inches. The roof is of tin and creosoted lumber, supported by six steel trusses. The

interior surface of the well house is of white enameled brick.

The interior well is supplied from the lake by eight ports through the timber wall. They are 7 feet square, with a sill elevation of -25.33 feet. Two shafts, 12 feet 3 inches inside diameter, extend from elevation $+8.5$ to the tunnel whose center line is at elevation -146 feet.

The upper sections of the shafts, extending down through the timber floor and to a water seal in the clay, are of $2\frac{1}{2}$ -inch cast iron. From there a 17-inch concrete lining extends through the clay and 4 feet into the rock; the remainder of the shafts is lined with 12 inches of concrete.



Fig. 7. Edward F. Dunne Crib Before Completion, Showing Footbridge.

In the third and fourth sections from the top of each shaft are six sluice gates providing in all twelve clear openings 5 feet wide by 6 feet 6 inches high; three in each shaft with a sill elevation of -21 feet, and three in each shaft with a sill elevation of -11.5 feet. These sluice gates are raised and lowered by $2\frac{1}{2}$ -inch rising screw stems, operated by hand from platforms over the intake shafts by means of bronze nuts in hoisting stands. Each gate opening is protected by a fish screen which can be raised or lowered from revolving derricks, one centrally located on each shaft platform. The cleaning of the screens will be done from hexagonal galleries encircling each shaft at elevation $+1.5$ feet. The maximum velocity at these gates is very low—about 1.6 feet

per second. It was considered that on this account the single screens would give sufficient protection, there being double screens at the station well.

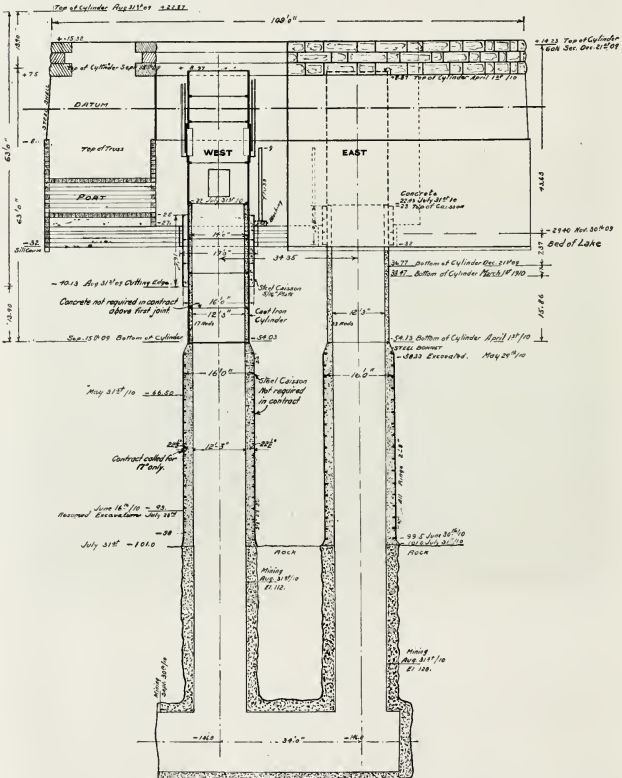


Fig. 8. Cross Section of Edward F. Dunne Crib.

The new crib is connected with the old crib, where the quarters of the operating forces are located, by a foot bridge. This bridge is 120 feet long and 7 feet wide, with a floor of 2-inch creosoted lumber. The trusses are of the simple Warren type,

8 feet 8 inches deep, all panels being equilateral triangles excepting for the camber.

The general cross-section of the new crib, as actually constructed exclusive of the parapet wall and well house, is shown in Fig. 8.

In order to provide for connecting the future extensions to the present system it was necessary to construct four gate shafts, with sluice gates which will shut off the water when the connections are being made.



Fig. 9. Interior View of Edward F. Dunne Crib.

After a thorough investigation, it was determined that it would be desirable to place 6-foot sluice gates in the 9-foot tunnel branches, thus requiring a gradual contraction from the 9-foot horseshoe section to the 6-foot circle. The resulting loss of head was computed to be 0.22 feet for an average velocity of 4 feet per second, or about 1 inch for 80,000,000 gallon daily flow.

Four gates controlling the flow in the land portion of the tunnel are placed one in each of the gate shafts on the four 9-foot branches. They come to a bearing in compression against the flanges of cast iron thimbles ($2\frac{1}{2}$ feet long) in the masonry when the station end of each branch is empty. The gates and hoisting mechanism were built by the Coffin Valve Company, according to

a special design made by the City. The gate is a section of a spherical surface. It is of cast iron 2 inches thick, stiffened with four 2-inch ribs on the inside. There is a 12-inch square opening with an auxiliary gate in each sluice gate acting as a by-pass and connected to the 3½-inch non-revolving rising stems, so that the sub-gate is mechanically opened in advance of the main gate. The operating machinery is placed on a concrete steel platform just below the street level. The revolving nut is placed so that the gates are operated from the street level and the upper threaded section of the stems is detachable. This arrangement was necessary so as to keep the operating mechanism out of the water and to avoid interference with traffic, the street grades in this territory being very low. The gate is made tight by the action of four seating clamps which draw the gate against its bearings while the stem is closing the gate.

Besides the general major contracts for Sections 1, 2 and 3, there were a few minor contracts, which, together with the contractors' names, are enumerated in the general summation of tunnel costs, shown below:

WORK.	COST.	NAME OF CONTRACTOR.
Lake borings.....	\$ 3,500	Great Lakes Dredge & Dock Co.
Section 1.....	603,494	Joseph Hanreddy.
Section 2.....	826,903	The Parker Washington Co.
Section 3.....	1,603,342	Jackson & Corbett, later contract assigned to Geo. W. Jackson, Inc.
Miscellaneous repairs to Sections 1 and 2, cleaning removing bulkheads, etc.....	22,668	George W. Gindele & Co.
Four 6-foot sluice gates	6,992	Coffin Valve Co.
Placing gates, Oglesby Av. extension, etc..	50,050	George W. Gindele & Co.
Parapet and well wall on Edw. F. Dunne crib.....	34,320	Paschen Bros.
Cleaning and pointing crib masonry	425	Paschen Bros. .
Roof, galleries, foot bridge, etc., for Edw. F. Dunne crib.....	8,656	John J. Gallery.
Total	\$3,160,350	

The Roseland Pumping Station was selected as the first station to be built in the system. It is an imposing structure, of massive design. The exterior walls are of hard-burned Moulding paving blocks on a high granite base course. The interior walls are Templeton gray and salt glazed brick, all laid in cement mortar. The smokestack is faced with Racine common brick on a granite base and granite trimmings.

The foundations are of monolithic concrete reinforced with steel grillings over pile clusters. There are 576 oak piles under the building foundation, and 165 under the stack foundation. The piles vary from 30 to 40 feet in length, depending on the elevation of the footings. They were all driven to elevation —20



Fig. 10. Roseland Pumping Station.

feet, which brought refusal. The condition of the building shows no indication of settlement.

The building is in two sections. The boiler room occupies the south section, with wings on either side for coal receiving room and repair shops. The engine room occupies the north section. The building faces north, the central entrance portico fronting on 104th street, opposite Harvard avenue. On either side of this entrance are the offices of the operating engineers, the engineer in charge of the station having his office on the west side of the entrance, and the engineers on watch on the east side. In the latter office is an iron stairway leading to a storeroom on the second floor, extending over the entire portico.

The engine room, 130 feet square in size, is located centrally over the tunnel shaft and the 100-foot circular engine pit. The

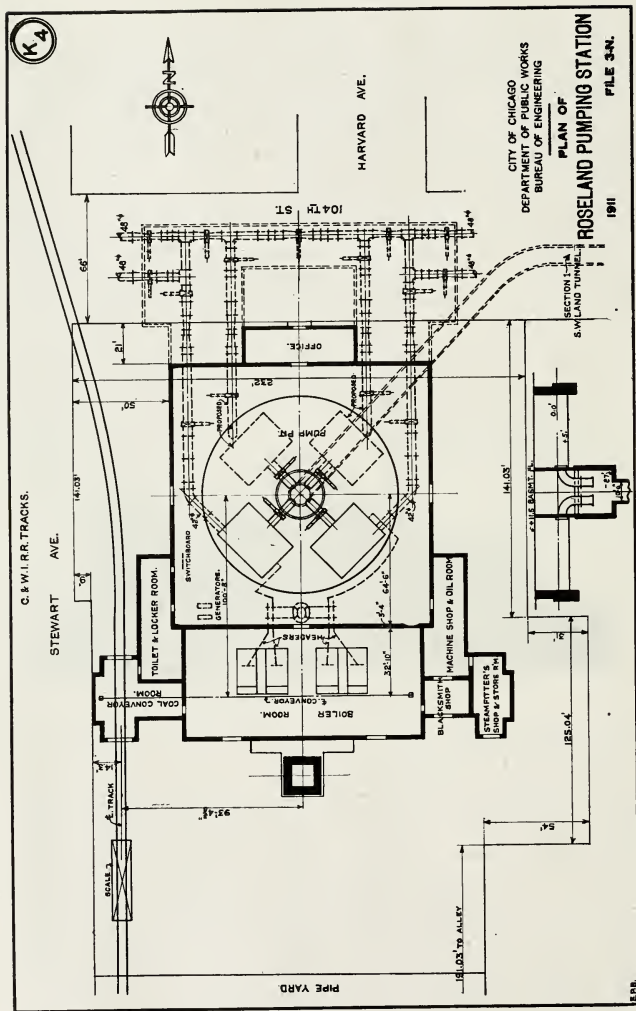


Fig. 14.

clear inside height from the engine pit floor, which is at -5 feet, Chicago city datum, to the horizontal lower chord of the roof, is 74.29 feet. The roof is of structural steel, being essentially supported by two diagonal trusses of approximately 38-foot rise. Upon this rests a slate roof, laid on yellow pine dressed and matched flooring, three inches thick.

The four pumping engines, which will be the ultimate capacity and of which two are now in operation, are situated in the above mentioned circular engine pit, the floor elevation of which is -5 feet. The circular concrete wall of this pit extends vertically to an elevation of $+11.5$ feet, where it meets the level of the basement floor. From this level the main concrete foundation wall of the building, 130 feet square, extends up to $+22$ feet, at which elevation the granite base of the superstructure begins.

The main engine room floor, at elevation $+24.5$ feet, surrounds the open engine pit, which here is 108 feet in diameter. This floor is supported on sixteen brick piers set on the circular concrete engine pit wall, and by the square foundation wall of the main building. The piers extend through the engine room floor, forming part of an ornamental iron and brass railing which surrounds the circular pit opening. The piers are topped off with granite caps, upon which are supported ornamental cast iron lamp posts. Each post has five incandescent lights, each inclosed in a crystal glass globe.

There are four projected landings at the edge of the engine pit, from which there are galleries connecting with the engines and ornamental stairs to the basement floor, at elevation $+11.5$ feet. From the top of the suction well to the basement floor on a line centrally between the two south pumps there is a gallery, affording access to the wet well platform. At the point where this gallery meets the wet well is mounted a hydrographic chronograph, which makes a continuous graphic record of the elevation of the water in the suction well.

The four engines in the engine pit are grouped around the central circular suction well and are located in the diagonals of the square engine room building. The suction well is situated centrally over the tunnel shaft. This shaft, 10 feet in internal diameter, extends from the tunnel, the center line of which is at -90 feet, to elevation -29 feet, where the wet, or suction, well proper begins, with an inside diameter of 23 feet. The floor of the well is a flat concrete slab 2 feet thick. The concrete wall of the well is 2 feet thick, from elevation -29 to elevation -8 . From this elevation the well is enclosed in a shell of structural steel plates

and angles, lined with 12 inches of reinforced concrete extending to the top of the well, at elevation $+11.5$, which is even with the basement floor of the engine room. In the wall of the well are four cast-iron suction glands with split packing rings, through which pass the 42-inch suction pipes of the pumping engines, the elevation of the center lines of which are -2.22 feet. The suction pipes, with 90-degree elbows, extend down to elevation -18 feet, where the ends flare to a 48-inch diameter. They are supported on two sets of 12-inch, 40-pound I-beams by means of lugs cast on the elbow sections of the suction pipes. The suction pipes are controlled by 42-inch, hydraulically-operated gate valves placed

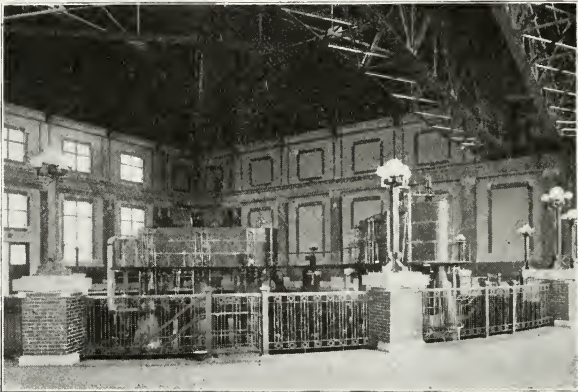


Fig. 12. Engine Room Completed, Looking Southeast.

just outside of the wet well. The southeast and southwest hydraulic valves are Kennedy valves, furnished as a part of the Allis-Chalmers company's contract for the first two, or south, engines. The northeast and northwest hydraulic valves are Pratt & Cady valves, purchased from the Western Valve Company, and installed by the Ketler-Elliott Erection Company.

Double sets of vertical fish screens are placed on the sides of the arms of a cross-shaped box enclosing the four suction pipes. The ends of the crossarms abut against the interior walls of the wet well, and the water enters the box through the fish screens from the four open quadrants formed by the crossarms in the circular wet well.

South of and adjacent to the engine room, extending its entire width, is the boiler room, 55 feet wide, at either end of which are the wings previously mentioned. The west wing contains the locker and toilet rooms, and the coal receiving and ash hoppers. The east wing contains various repair shops and storage rooms. The smokestack, 8 feet inside diameter, and 180 feet high above the grates, is immediately south of the station on an independent foundation described before.

The two south pumps and accessories were erected under a contract with the Allis-Chalmers Company, amounting to \$261,100, and cover the following items:

- One 25-ton electrically-operated traveling crane, 127 feet 4 inches span.

- Two vertical, triple-expansion, self-contained crank and fly-wheel condensing pumping engines, each of 25,000,000 daily capacity, with steam jacketed cylinders, reheating receivers, and single-acting outside packed plungers.

- Two 42-inch suction lines with valves, surface condensers, and feed water heaters.

- Two 42-inch discharge lines to points 5 feet outside of the building, with direct flow Venturi meters with recording mechanism.

- Two direct-connected air pumps and boiler feed pumps.

- One independent air compressor and receiver.

- One independent air pump.

- Two steam separators.

- Two oil separators.

- Two oil filtering hot wells.

- A complete testing equipment and all necessary gauges, wrenches, indicators and thermometers.

The following is a tabulation of the essential data as to the design of these two engines:

- Capacity, 25,000,000 U. S. gallons in 24 hours.

- Head, total normal, 140 feet.

- Head, total, maximum, 200 feet.

- Steam pressure at throttle, 170 pounds gauge pressure.

- Rotative speed at rated capacity, 25 R. P. M.

- Plunger speed at rated capacity, 250 feet per minute.

- High pressure cylinder, 24-inch diameter, 60-inch stroke.

- Intermediate-pressure cylinder, 46-inch diameter, 60-inch stroke.

- Low pressure cylinder, 70-inch diameter, 60-inch stroke.

- Pump plungers, 34-inch diameter, 60-inch stroke.

Main journals, 16-inch diameter, 30 inches long.

Crank pins, H. P. and L. P., 8-inch diameter, 8 inches long.

Crank pins, I. P., 12-inch diameter, 8 inches long.

Crosshead pins, 7½-inch diameter, 7½ inches long.

Wheel diameter, 18 feet. Approximate weight of each, 40,000 pounds.

Diameter of shaft in wheel pit, 18¼ inches.

Diameter of pump valves, 3⅝ inches.

Pump valve area, suction and discharge, each chamber 1,347 square inches.

Pump valve area, 148 per cent of plunger area.

Number of valve cages to each suction and discharge deck, 7.

Number of valves to each cage, 35.

Area of cooling surface in surface condenser, 100 square feet.

Air pump, single, 22-inch diameter, 60-inch stroke.

Diameter of suction pipe, 42 inches.

Diameter of discharge pipe, 42 inches.

Area of heating surface in feed water heater, 100 square feet.

ESTIMATED WEIGHTS IN POUNDS.

Steam engine proper	693,000
Condensing outfit	60,000
Water end	583,000
Complete pumping engine.....	1,340,000
Crane, steam, feed, suction and discharge pipe, gate valves, extra galleries, etc.....	310,000
Total	1,650,000

The steam cylinders of the pumping engines are steam jacketed and there is a re-heating receiver between the high and the intermediate and between the intermediate and the low pressure cylinders. The condenser is a surface condenser of the Wheeler type and is designed to maintain a vacuum within 2 mercurial inches of the barometer. The condenser is located in the suction pipe between the hydraulic valve, previously described, and the main pump body of the pumps. In this way the suction of the pumps passes through the condenser, furnishing the cooling water for same. The exhaust of the condenser is so arranged that it may be by-passed through a primary feed-water heater. There is an oil separator in the exhaust steam line before it reaches the primary heater and condenser, which removes practically all the oil, the

balance being removed by the feed water heater and purifier in the boiler room.

Each engine is provided with a direct-driven air pump, direct-driven feed pump and direct-driven air compressor. There is

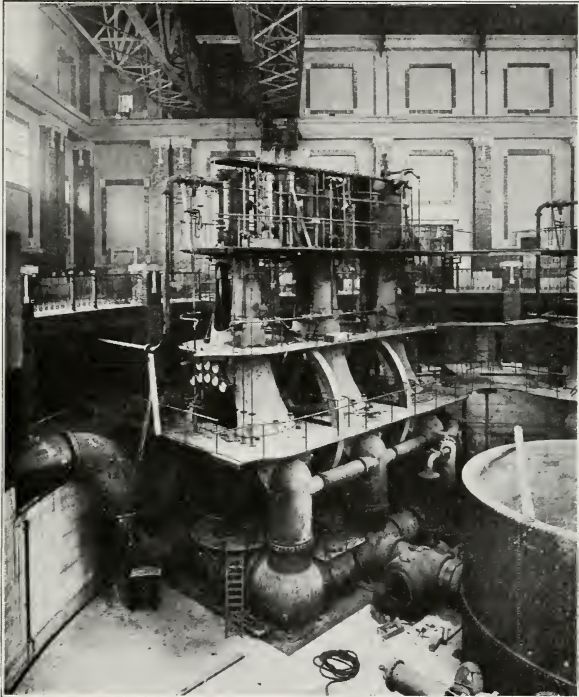


Fig. 13. Engine Room During Construction, Showing Southeast Pump in Pit.

also an independent air compressor and an independent air pump for use in starting the engines.

There is an automatic oil system so that it makes it unnecessary to handle any oil in the plant after it has been deposited in the tanks of the oil room. These tanks, four in number, were furnished by the Wayne Oil Tank Company, and are provided with a barrel track and splash board, so that the emptying of oil barrels

into these is done with a minimum of handling. They are also fitted with self-measuring pumps and float gauges, so that the quantity of oil in the tanks can easily be ascertained. The two larger tanks, each of 6 barrels capacity, are used for engine and cylinder oils, and are connected by 2-inch brass pipe lines, provided with quick-opening valves, to two cylindrical supply tanks, which are supported near the floor, on the south wall of the engine pit; a gravity feed to these supply tanks is insured. The oil is pumped from the supply tanks to a third pair of tanks supported above the crane rail on the north wall of the boiler room. Connections lead from the lower of these tanks to all bearings, guides, etc., on machinery, and from the upper tank to the engine cylinders. The used oil runs through the system on the engines and the returns are collected into a reservoir, from which it is pumped into oil filters supported on the south wall of the engine pit. The filtered oil is pumped from a drip reservoir under the filter into the gravity engine-oil tank on the boiler room wall, together with additional new oil for make-up.

The station throughout is electric lighted and all the auxiliary power, such as is necessary for operating bilge pumps, crane motors, coal conveyor motors, repair shop motors, etc., is also electrical. Electric current for power and light is furnished by two General Electric, 75-kilowatt, 125-volt, direct current generators, directly connected to two Corliss horizontal impulse turbines, running at 3300 R. P. M. In the summer the exhaust from these turbines goes to the feed water heater in the boiler room or runs condensing as desired. In the winter the exhaust steam is used for the heating system of the station.

All wiring for power and light is run through iron conduits concealed in the walls and floors, from the main switchboard to metal feeder cabinets distributed throughout the building in convenient locations. From these the power is distributed through conduits directly to a motor or a circuit of lights.

The discharge pipes, with center lines at elevation $+11.5$ feet, lie in shallow trenches in the basement floor and pass through cast iron thimbles in the north foundation wall of the engine room. The elevation of the center line of these thimbles is $+16$ feet. This rise in the discharge pipes is accomplished by using two one-eighth turn elbows.

North of and adjacent to the north foundation wall of the engine room and under the roadway of 104th street is constructed a discharge pipe vault. In plan this vault is 161 feet east and west, and 70 feet north and south. It is U-shaped, with the base

of the U extending east and west in 104th street. The four discharge lines from the station lie in the short arms extending to the building. These discharge lines are connected to two main feeder lines, 48 inches in diameter, running east and west in 104th street. Nine 36-inch and two 42-inch hydraulically operated gate valves are so placed on the discharge pipes in the vault as to control the flow from any or all discharge pipes to any or all of the feeders. A Venturi meter, 28 feet 10 inches long, is placed on each discharge pipe in the vault between the feeder main and a point 4 feet 5 inches outside of the main building foundation. A check valve is mounted on each discharge line between the Venturi meter and the pump.

The discharge pipe vault is heated by fifteen radiators set on iron stands and is wired with twenty-four incandescent lamps for lighting. The plain 6-inch concrete floor of the vault is at elevation +12.5 feet, which permits of its drainage into the street sewer. The walls are of reinforced concrete, 12 inches thick. Forty-four 5-inch cast-iron columns support 15-inch I-beams, on which rest reinforced concrete slabs 10 inches thick under the roadway and 7 inches under the sidewalks and parking. The roof of the vault was waterproofed with three-ply No. 6 Sarco waterproofing applied when hot on a priming coat. The layers extend one foot down on vault walls and one foot up at junction with building walls.

The steam supply required for the eventual capacity of 100,000,000 gallons pumpage is to be furnished by a complete plant of six 300-horsepower boilers. The present equipment consists of two batteries, of two Edge Moor water-tube boilers, each of the following description:

Two horizontal circular longitudinal drums, $25\frac{1}{8}$ inches in diameter.

Box headers and 150 4-inch tubes, 18 feet long.

Total heating surface, 2970 square feet.

Working pressure, 175 pounds.

Besides the usual valve equipment, each boiler is fitted with a fusible plug, a high and low water alarm, and a reflex water gauge.

The boilers are fitted with Illinois Stoker Company's chain grate stokers of the horizontal continuous feed type with interlocking grates. The feeding of the four stokers is operated by eccentrics on two shafts mounted above each, driven by either of two stoker engines, E. H. Wachs Company's type E.

The following are various data pertaining to the grates:

The weight of one stoker complete on rails, 29,250 pounds.

Weight of chain only, 14,325 pounds.

Per cent of air space, 27.

Effective grate area, 61 square feet.

Coal burned per hour per square feet, with 0.25-inch draft, 25 pounds; with 0.35-inch draft, 35 pounds.

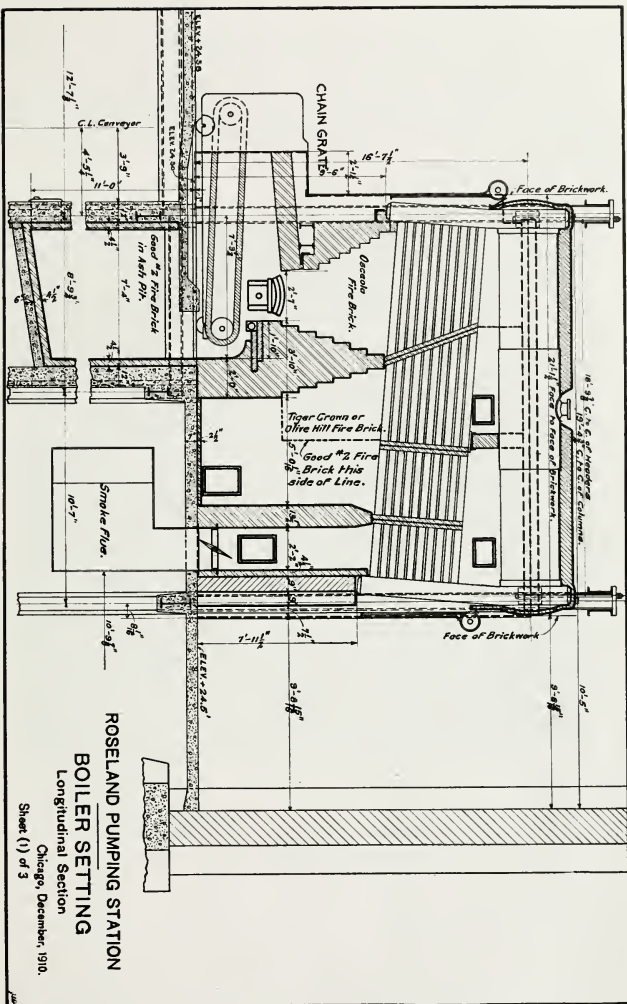
The baffle plates and bridge wall in the boilers are arranged to give a four-pass vertical passage through the boiler, emerging downward at the rear of the setting where the gases enter the horizontal suspended steel flues in the basement. The east and west flue branches meet on the center line of the building and turn south independent of each other to the south foundation wall, where they stop and the draft is combined, entering a brick lined passage through the foundation wall and into the base of the stack. Each branch is fitted with two clean-out doors and two expansion joints. The interior of the bottom of the stack can be cleaned from a passage below the smoke flue.

The steam mains are piped from each boiler down through the floor near the north wall of the boiler room. Beneath the floor these pipes make a bend through the wall into the south end of the engine room, where a connection is made with a double header. All four boilers connect with each header, but the arrangement of the valves is such that either header can be cut out when desired. The pumping engines take their steam from these headers through 6-inch pipes provided with steam separators properly trapped.

All piping is coupled by steel flanges, welded to the pipe. The piping layout has been particularly well worked out and is an admirable combination of efficiency and simplicity.

The steam plant is equipped with one 48-inch blow-off basin, one 26-inch blow-off basin, two boiler feed pumps, and one open feed water heater.

The pumps are of the vertical, duplex, double-acting, outside-packed, direct-acting type. They are bronze fitted throughout, each having a capacity of 80 gallons per minute against a maximum boiler pressure of 190 pounds when supplied with steam at 160 pounds at the throttle and running at a speed of 40 single strokes per minute per plunger. The boiler feed lines are equipped with two Venturi hot water meters for 2-inch pipes reduced to $\frac{3}{4}$ -inch at the throat. They are designed to be capable of measuring 55 gallons per minute each at a temperature of 210° Fahrenheit and a working pressure of 190 pounds. The quantities of



water measured are shown on a rate indicator and on a recording chart.

A Stillwell improved open-feed water heater and purifier, of 1,000 horsepower capacity, is placed adjacent to the center of the south boiler room wall. The heater conforms to the following specifications:

Space occupied, 4 feet by 10 feet 4 inches by 11 feet 2 inches high.

Exhaust inlet, 5 inches.

Exhaust outlet, 6 inches.

Overflow, 3 inches.

Live steam inlet, 3 inches.

Pump suction, 5 inches.

Cold water inlet, 3 inches.

Chemical inlet, $\frac{1}{2}$ -inch.

Two blow-offs, $2\frac{1}{2}$ inches.

The boiler room floor is of reinforced concrete slabs, supported by enclosed steel beams on steel columns. The floor is designed for a uniform live load of 200 pounds per square foot, and for the concentrated loads of boilers and stokers. The beams are supported by steel columns resting on piers in the basement. The coal bunkers are supported on steel columns passing through holes in the boiler room floor and resting on independent piers. The flat reinforced concrete roof is supported by six steel trusses which span the entire room and also carry the coal conveyor.

Coal is received from cars on tracks of the Chicago & Western Indiana Railroad. The side track running south from a trailing switch north of 104th street passes through the conveyor house, which forms the major part of the west wing of the station. This conveyor house contains a square elevated structural steel, concrete lined ash bunker, mounted on two steel columns with foundation piers inside but independent of the building. The hopper is adjacent to the track, and is fitted with a compound spout, so that ashes can be emptied either into cars on the track or into wagons which can be backed from the south into the building. There is a receiving hopper about 20 feet square under the track which is supported on two 20-inch I-beams. Under the outlet of this hopper is a motor-driven coal crusher, designed to crush bituminous coal from run of mine to $1\frac{1}{4}$ -inch size, or to give a clear opening for direct feeding into a continuous pivoted bucket carrier. The continuous carrier runs east and west around the boiler and conveyor rooms in a vertical plane about four feet south of the south front of the boilers. An apron feed moves the

coal from the hopper, east into the crusher, thence down into the buckets with center line at elevation $+7.67$ feet, thence west and upward to the roof where the motor drive is mounted, thence on a slight upgrade over the ash hopper into the lower part of the boiler room roof trusses with center line at elevation $+73.76$ feet, thence east on a horizontal line over the coal bunkers to the east wall of the boiler room, thence down to the basement to a line just



Fig. 15. Boiler Room, Looking West.

below the boiler room basement floor with center line at $+10.42$ feet in a trench which passes the ash pit doors, thence to the west end of the boiler room where it dips on a slope into the crusher pit. Both vertical runs are enclosed by steel casing and an ash guard protects the chain in the trench. The carrier conveys either coal or ashes. A stationary dumper or bucket trip is provided over the ash hopper and two traveling dumpers over the coal hoppers. The dumpers can be operated from below. The ashes are fed into the conveyor through removable aprons sloping from the ash pit doors to the conveyor.

There are four bunkers, in pairs of two, or one for each boiler at present installed, leaving room for two single bunkers for the boilers required for the eventual capacity of the station. Each pair of bunkers has a capacity of 170 tons. The single bunkers are to be designed for 90 tons, and the ash hopper is designed for 60 tons of wet ashes. The conveyor carries 40 tons per minute when traveling 40 feet per minute.

There are three separate drainage systems. The first, or lowest, provides for drainage in the pump pit, and consists of a gutter along the circular pump-pit wall discharging into two sumps, 3 feet in diameter and 6 feet deep, located on the east and west sides of the pump pit. The sumps are cross-connected under the floor by means of a 6-inch vitrified tile sewer. The west sump is provided with an electric bilge pump controlled by a float valve and automatically empties the sump through a discharge connecting with the main 9-inch sewer leading from the station. The east sump is provided with a steam ejector connected to the same sewer, for use in case the bilge pump fails.

The second system drains all the basement floors and the conveyor trench and pit. These drains are collected into a cast-iron sump located in the conveyor-room basement and are discharged by means of a similar electric bilge pump discharging into the main sewer of the station.

The third, or upper, drainage system provides for surface drainage and drains from the roofs, main floors and toilet rooms.

All the drainage eventually goes to two manholes south of the station into the sewer on 104th place. The elevation of the end of this sewer is + 13.25 feet.

A Fairbanks-Morse, 100-ton, 40-foot track scale with dead rail is located 40 feet south of the station on a concrete foundation built by City labor. This track scale in this location is used both by the pumping station and the city pipe yard, situated immediately south of the pumping station, between 104th place and 105th street.

The yard space between the pipe yard and the boiler house has been paved with vitrified Athens paving block, laid on 6-inch concrete foundation with 1-inch sand cushion. One hundred and fourth street, in front of the pumping station and over the discharge pipe vault, has been paved with a creosoted block roadway 30 feet wide from the railroad east as far as the city property extends. Cement sidewalks have also been laid around the station and the grounds improved with lawns and shrubbery. The paving and improvement of grounds was all done by City labor at a reasonable cost.

The various elevations (in feet) in and about the station are as follows:

Pump pit floor.....	—	5.
Center lines of suction.....	—	2.22
Conveyor pit floor.....	+	5.75
Basement floor	+	11.5
Discharge pipe trench	+	8.5
Center line of discharge pipe.....	+11.5 and +	15.90
Sewer grade, south of station.....	+	13.25
Office, main engine room and boiler room floor.....	+	24.5
Established grade of street curb on 104th St.....	+	21.8
Grades on grounds	from +22 to +	24.5
Track grade at hopper.....	+	26.0
Office store room floor.....	+	40.5
Office section roof	+	55.0
Office section parapet	+	58.60
Top crane rail	+	56.38
Bottom chord roof trusses, engine and boiler room.....	+	69.29
Apex intersection of roof trusses.....	+	107.92
Apex of skylight of roof trusses, approximately.....	+	111.25
Boiler room roof	+	77.70
Top of circular 18-inch lining in stack.....	+	84.5
Top of circular 9-inch firebrick lining in stack.....	+	144.5
Top of chimney	+	207.0
Floor of pattern storage.....	+	41.25
Floor of carpenter shop.....	+	56.25

The following dates on the construction are listed for record and will show the progress of the work:

ROSELAND PUMPING STATION.

WORK.	DATE COMMENCED.	DATE COMPLETED.
Engine room foundations.....	4- 8-09	3- 9-10
Boiler room foundations	10- 5-09	3- 9-10
Superstructure	3- 7-10	3-25-11
Concrete floors, boiler room	5- 8-11	7- 7-11
Other concrete floors	7-25-11	10-15-11
Plumbing	5-15-10	2-15-12
Discharge pipe vault	9- 5-11	12-19-11
Engine foundations	10- 7-10	11- 9-10
Engine installation (Allis-Chalmers)....	3-22-11	*12-23-11
Four boilers	3- 6-11	4-18-11
Four boilers, setting.....	7- 1-11	9- 5-11
Four chain grate stokers.....	5-15-11	9-15-11

*Commenced pumping.

WORK	DATE COMMENCED.	DATE COMPLETED.
Four coal and ash bunkers.....	9- 7-11	11- 7-11
Coal and ash handling machinery.....	10- 2-11	11-18-11
Smoke flues	8-22-11	10-15-11
Power piping	9- 1-11	11-22-11
Pipe covering	10- 2-11	12-28-11
Fishscreens	6-14-11	9- 7-11
Lightning rod on chimney	9-18-11	9-29-11
Turbo-generator set	3-19-12	9-15-12
Switchboard	7-15-12	1- 7-13

The following is a list of construction costs of the station:

WORK.	COST.	STATION SITE. NAME OF CONTRACTOR.
Real estate.....	\$ 8,110	Various owners
Harvard av. paving....	2,125	The Parker-Washington Co.
Sewers	861	City forces
Grading, paving, etc....	18,553	City forces
Track scale.....	1,125	Fairbanks, Morse & Co.
Track scale foundation.	1,734	City forces
Track scale rails, etc....	580	C. & W. I. R. R.
Protecting main tracks.	499	C. & W. I. R. R.
Vault steel.....	4,130	John O'Brien
Vault concrete.....	12,994	City forces
Vault waterproofing....	1,355	City forces
	<u>\$52,066</u>	

BUILDING.

Eng. house foundation.	\$52,188	The Parker-Washington Co.
Boiler house foundat'n.	18,425	The Parker-Washington Co.
Superstructure	228,325	The Warner Construction Co.
Plumb., heating, etc....	10,500	Carl John Stein
Painting	3,470	R. G. Elton
Painting	2,227	Water Works Shops
Lightning rods.....	350	Ajax Conductor & Mfg. Co.
Boiler room floors.....	3,250	F. W. Myrick
Basement and pit floors.	5,833	Standard Concrete Const. Co.
Cast iron lamp posts...	523	Dearborn Foundry Co.
Lockers	648	F. P. Smith Wire & Iron Wks.
Basement windows.....	420	Jas. A. Miller & Bros.
Galleries, platforms, etc.	687	Standard Arch. Iron Works
Conveyor rm. clg. steel.	410	John G. O'Neill
Shelves and partitions..	217	M. H. Hickey Wire & Iron Wks.
Gallery in conveyor pit.	195	John G. O'Neill
Miscellaneous bldg. wrk.	647	Various firms

Steam fitting, etc.....	1,408	City forces
Vault heating system..	764	City forces
Engine pit h't'g system..	165	Peter S. Olson & Co.
	<u>\$330,652</u>	

EQUIPMENT.

Two engines & crane..	\$261,100	Allis-Chalmers Co.
Two engine foundat'ns.	3,630	Am. Eng. & Const. Co.
Turbo-generators	7,894	Western Electric Co.
Switchboard	1,425	Receivers, Allis-Chalmers Co.
Pipe covering	5,725	M. M. Wagner
Open feed-water h't'r..	888	The Platt Iron Works Co.
Four boilers	14,640	Edge Moor Iron Works
Boiler setting.....	4,195	Jos. T. Dorgan Co.
Smoke flues.....	3,855	John Mohr & Sons
Smoke flues.....	703	T. F. Downey
Four stokers	4,190	Illinois Stoker Co.
Coal and ash bunkers..	8,779	J. C. Roemheld
Ash spouts.....	400	John Mohr & Sons
Coal and ash handling machinery	8,300	Link-Belt Co.
Valve gallery.....	160	John G. O'Neill
Furniture	232	Scholle Furniture Co.
Crane stop	440	Carl Anderson Co.
Electric wiring.....	6,695	City forces
Two suction pipes.....	2,027	Jas. Brady Fdy. Co.
Two suction valves.....	1,494	Western Valve Co.
Screens and erection..	3,895	Ketler-Elliott Erection Co.
Moving 3rd engine from Lake View pumping station and furnishing 4th eng..	118,000	Bethlehem Steel Co.
Power piping.....	11,520	Henderson Co.
Oil tanks.....	390	Wayne Oil Tank Co.
Oil pipe lines.....	267	Peter S. Olson & Co.
Furniture	171	Various firms
Foot-bridge in well....	255	John G. O'Neill
	<u>\$480,297</u>	

The entire cost of the present system, including both tunnels and Roseland Pumping Station, exclusive of engineering and inspection, is \$4,023,365.

The writer is indebted to Mr. F. C. Martini, assistant engineer, for assistance in compiling the data for this article.

MODERN PRACTICE IN HIGH TENSION TRANSMISSION.

BY LOUIS ELLIOTT, E. E.*

This brief discussion is intended as a general description of good current practice and little new matter will be found therein by the transmission engineer.

The line of demarcation between transmission and distribution lines is not well defined, although in general transmission of electrical energy is had from a source to some center, whence distribution lines radiate to the consumers of this energy. The usual maximum for a distribution voltage may be set at 11 to 13 kilovolts, the chief reason for this being that above this voltage outdoor service transformers become very expensive; 22-kilovolt lines are not uncommon for certain country distribution, but at this voltage transformers are too expensive for small consumers. The term "high tension transmission" is also rather indefinite, inasmuch as the art is advancing so rapidly, and the term may be applied to any voltage between 30 and 175 kilovolts, and even outside these limits.

Present-day practice in high tension transmission calls for the use of galvanized steel towers, both for safety and permanence, although a considerable number of lines in districts such as the Pacific Northwest, where heavy poles are cheap, have been constructed on poles or timber bents. In at least one case poles completely treated with creosote have been used, but these were found to be so heavy, so hard to handle, and so extensive that the experiment was not counted a success. Concrete poles and steel poles, especially the latter, are used for the lower voltages. Longer spans may be employed with good steel poles than with timber, and for some conditions they make a very desirable type of line.

The general practice in this country is the use of the square steel tower for all supports in the line, although in certain instances and quite widely in Europe a semi-flexible type of support, strong in a direction transverse to the line, but flexible in a direction along the line, has been used, with anchor towers every mile or two. These bents are especially suitable for use with the horizontal arrangement of conductors; they may be designed so that in case the conductors break the flexible structures will not fail entirely, but will bend away from the break

*Class of 1899. Engineer, Electric Bond & Share Company, New York City.

in each direction up to the next anchor tower. One disadvantage of this design is that at least two widely different structures must be used for the line, or undesirable guys must be used at the anchorages.

A favorite arrangement for conductors, in the case of two-circuit structures, is two vertical sets of three wires each. This permits the killing of one circuit and working on it while the other is still hot, and also allows the failure of one circuit without harm to the other. The chief disadvantage of this arrangement is in districts where sleet is to be expected, and trouble may be experienced from one conductor sagging and fouling a second. So far as wind alone is concerned, the vertical arrangement of conductors is probably the better.

Tower design varies from the radical, in which the material may be stressed to the elastic limit under extreme conditions, to the comparatively conservative, in which a factor of safety of three or more is used. Corner angles as thin as $\frac{1}{8}$ inch have been used, but the general practice tends to $\frac{3}{16}$ -inch or heavier angles for corner columns. The usual specifications for tower tests call for the application of forces in various directions equivalent to or somewhat more severe than the most unfavorable line conditions which may be expected, and require that practically no permanent set shall be produced. A few typical examples of practice will be cited.

A power line in the southwestern part of this country uses towers with $\frac{1}{8}$ -inch corner angles, weighing 1,300 pounds each, and with a spacing giving ten towers to the mile; two 45-kilovolt circuits are run on two-unit suspension type insulators. In order to test this tower, a sample span 500 feet long was set up, with the seven wires (including ground wire) stretched more tightly than they would be in the actual line, and then all seven wires were cut on one side of the tower. The tower deflected about 8 inches, but upon the stress being relieved returned practically to its original position. In comparison with other designs, this structure is an exceedingly light one for the service.

Another tower line, operating at 100 kilovolts, is about 150 miles long and carries six No. 000 wires with the lowest about 50 feet from the ground; there are about 1,000 standard towers weighing 3,500 pounds each, and 75 angle towers weighing about 10,000 pounds each, with a number of special high towers for crossing highways; the maximum span is 2,700 feet. It was at one time intended to use anchor towers intermediate in strength between the standard and the angle type, these to supplant fifty

of the standard towers at dead ends and at light angles in the line, but this change was not made; the standard towers are designed for stresses resulting from wind and cable weight only, with a safety factor not exceeding two. Although these light towers have been retained for most of the dead ends and smaller angles, no failures have been recorded except in the case of failure of the anchorage. A considerable number of towers fell from this cause at a time of excessive rain, which softened the footing beyond the danger point; correction was made by placing concrete around all tower footings. Fig. 1 shows the general form of this tower.

A third power line, also 100-kilovolts and about 150 miles long, uses single circuit towers for three No. 0 conductors; the average number is seven to the mile, and the maximum span about 2,900 feet. Fig. 2 shows the tower equipped with strain insulators. The average country passed over is exceedingly rough and the climatic conditions unusually severe, as the line crosses the continental divide three times between the power house and the terminal substation; Fig. 3 gives an idea of the territory traversed. The towers have in general proved satisfactory, although a few failures have been experienced on account of very severe conditions; from various tests it has been computed that the wind occasionally reaches a velocity of 100 miles per hour across one of the passes. These towers have been guyed in a large number of instances.

The tests specified for the towers used on the last described line were as follows, acceptance being based on their success in withstanding tests No. 1, 2, 3, and 5 with slight permanent set; temporary and permanent deflections are given in each case.

1. 2,500 pounds in the direction of the line from the end of the crossarm; deflection 4 inches, and permanent set 0.25 inch.

2. 2,500 pounds parallel to the line from the middle of the crossarm; deflection 0.75 inch, and permanent set 0.5 inch.

3. 2,000 pounds down from the end of the crossarm; deflection 1.75 inches, and permanent set 0 inch.

4. This test was similar to test No. 1, except that the force was increased, the deflection at 3,700 pounds being 5.6 inches and permanent set 1 inch, and at 4,500 pounds the deflection was 15 inches.

5. 6,000 pounds at right angles to the direction of line from end of the crossarm; deflection 2.5 inches, and permanent set 0.25 inch.

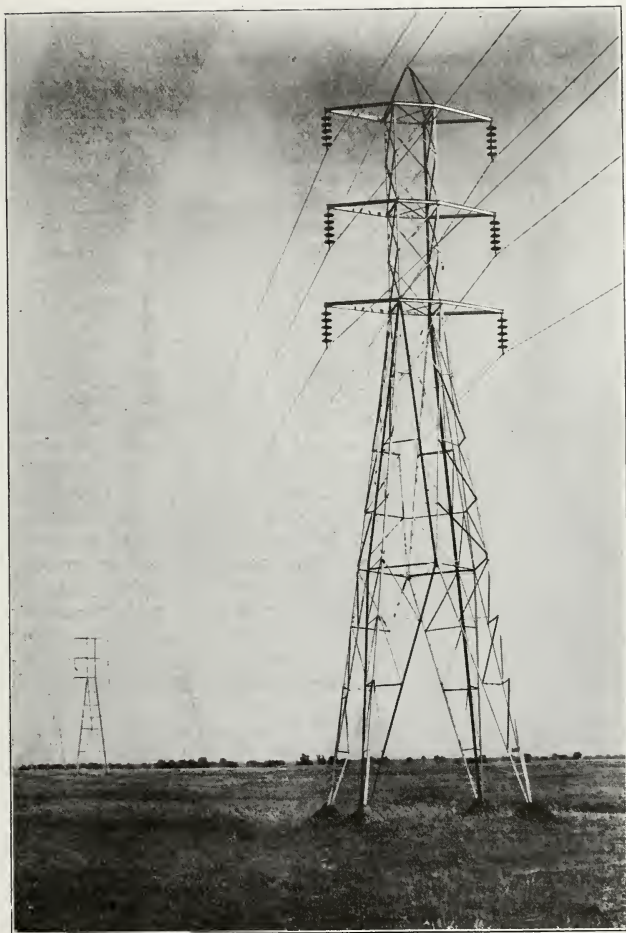


Fig. 1. Typical Towers for High Tension Transmission.

6. This test was similar to test No. 5, except that the force was increased, the deflection at 9,000 pounds being 5.3 inches and the set 1 inch, and at 9,500 pounds the deflection 9 inches, with subsequent failure.

The results of tests No. 1, 2, 3, and 5 showed practically no permanent deformation, test No. 4 showed deformation in the crossarm only, and the final force applied in test No. 6 was the only one causing failure of the tower.

As a fourth example, the Southern Pacific specifications may be cited, calling for a factor of safety of three in all parts of the tower structure, with full stress in all conductors in one direction, those in the other being considered as cut; under extreme conditions the weight of earth or concrete resisting uplift at any tower leg anchorage must be twice as great as the maximum uplift.

As a high tension conductor, hard drawn copper is still the favored metal; it is usually stranded, as it is difficult to string solid wire without injuring it, and a slight nick in the hard surface caused by the process of drawing will cause failure in the wire. The tensile strength of the completed cable is not less than 55,000 pounds per square inch, and the elastic limit of each strand about 35,000 pounds. Some engineers, however, favor aluminum and it has been largely used; on account of the present high price of copper the use of aluminum is receiving an added impetus. It is in general inferior to copper in mechanical as well as electrical properties, and must be handled with great care; difficulty has been experienced in supporting the conductor without doing injury to the strands and causing failure. On the other hand, it is lighter to handle, and the large surface of the aluminum conductor is favorable from the point of view of corona loss. A new type of conductor which has not yet been widely introduced consists of stranded aluminum with a high grade steel core, and it is now intended to use this on some important lines in the course of construction. For very long spans copper-clad wire, consisting of copper rolled to an intimate union with a steel core, is often used, the elastic limit of this duplex material being about 100,000 pounds per square inch, and of the stranded cable as made up about 90,000 pounds.

It is usually the practice to string a grounded wire above the power conductors in countries where lightning disturbances are to be expected. Although it is very difficult to arrive at the absolute value of this ground wire, it is usually conceded to be a desirable thing, and is commonly installed where conditions

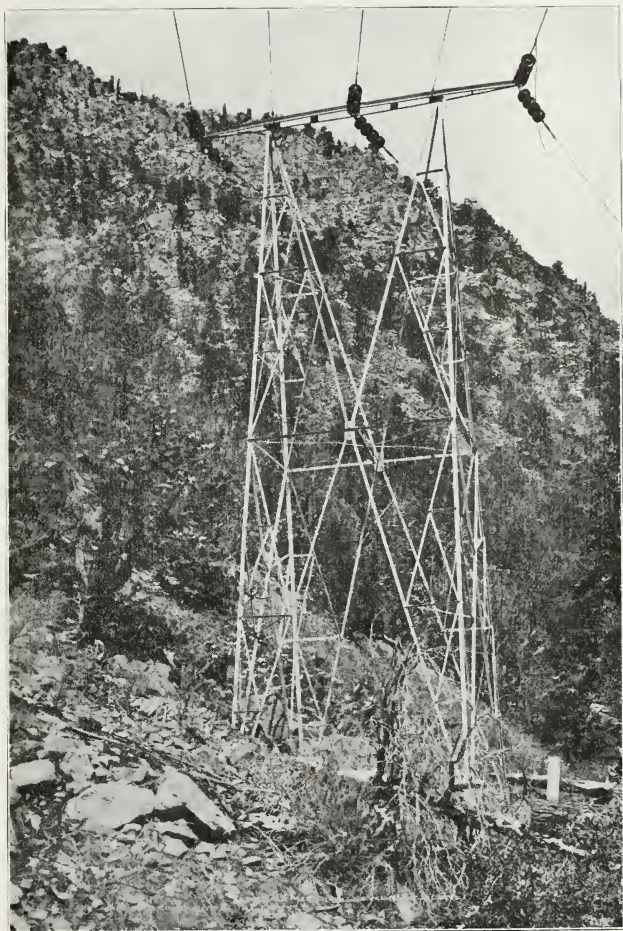


Fig. 2. Transmission Tower at Curve.

allow. The commonest material for this is Siemens-Martin galvanized steel strand; for the usual tower line $\frac{1}{4}$ -inch is somewhat small, and $\frac{5}{16}$ - or $\frac{3}{8}$ -inch should be used. The general function of the ground wire is to shield the power conductors from atmospheric electrical disturbances, equalizing the potential stresses by providing an easy discharge to ground instead of introducing dangerous strains in the line insulation. It is said that certain protection is afforded to power conductors between planes extending down 45 degrees from the vertical in each direction from the ground wire. Various other devices have been tried, and some of them proven successful, such as the arcing rings for the protection of insulators, designed by Mr. Nicholson and installed on a Niagara Falls line.

For voltages in excess of 60 kilovolts the suspension insulator has become almost universal, the ordinary suspension disc being rated at from 15 to 30 kilovolts and being used, for example, on 100-kilovolt lines, four to six in a string, with five as an average. One of the first forms of the suspension insulator was the inter-linked type, made by the General Electric Company, in which the porcelain between the links was in compression. It has not been found, however, as strong mechanically, nor to give as good potential distribution, as the later type. A standard type which is now manufactured by several of the larger companies consists of a rather small disc with a series of concentric rings or petticoats on the under side. The hardware detail on the top is usually a hollow cone into which the insulator is cemented, and this is found to give a better potential distribution than other forms. The mechanical connection between the hardware cemented into the bottom of the insulator and the cone on the top of the next unit, is of various types, such as hook and eye, clevis and eye, or ball and socket. In general, the surface of such hardware should be smooth and without projections, in order to prevent static discharge and tendency to puncture and flashover. One disadvantage of this type with the comparatively small mass of porcelain and the small petticoats is that in some districts, such as the Pacific Coast, where salt fog occurs, salt or dirt may collect and make flashovers more frequent and cleaning difficult. For such districts it is quite possible that a larger disc with a smoother porcelain surface is better.

As an example of the commercial insulator on the market today, the following is copied from specifications put out by one of the leading manufacturers. The insulator is in the form of a disc, and is normally used as a suspension unit, but if used as a strain



Fig. 3. Transmission Line Near Hell Gate.

insulator it is recommended that one additional disc be used for each voltage.

Dry test voltage (single unit).....	70,000
Rain test voltage (single unit).....	48,000
Leakage distance (single unit), inches..	10
Arcing distance (single unit), inches....	4.75
Net weight per 100, pounds.....	950

Units are recommended to be used as follows:

Line voltage.....	44,000	2 units
Line voltage.....	66,000	3 units
Line voltage.....	88,000	4 units
Line voltage.....	110,000	6 units

Outside of injury from malice and of an occasional mechanical failure, the chief dangers to the suspension insulator are from puncture and flashover, and these problems have been treated in a very instructive way in a recent paper before the A. I. E. E. The statement is there made that high frequency surges tend to cause puncture in insulators which have successfully passed through the usual 60-cycle tests in the factory. The point of flashover depends on the leakage and arcing distances, on the condition of the surface as to moisture and cleanliness, on the condition of the air, and on the form taken by the hardware. The puncture voltage depends upon the frequency, upon the thickness and quality of the porcelain, and upon the distribution of potential stress, which last is determined largely by the form taken by the hardware.

These statements also apply to the strain type of insulator, but in this type a much greater mechanical stress must be provided for. The design of the strain insulator is often the same as that of the suspension, except that the neck is made longer to give a greater tensile strength to the insulator, that is, a greater adhesion between the porcelain, the cement, and the hardware. It is often found that a large share of the troubles with high tension line insulators are at the dead ends, one company recording at least ten failures of strain insulators to one of suspension. It is sometimes considered that a combination of mechanical and electrical stress is more severe than electrical alone, and a series of tests would be desirable, attempting to show some relation between varying mechanical stress applied to a strain insulator and the point of failure at a fixed applied e. m. f. By others these failures are laid to mechanical troubles merely. It is usually difficult to ascertain after the failure of a string of strain insu-

lators whether such failure was first mechanical or electrical. Some companies have taken out strain insulators as far as possible, taking all minor deflections with suspension insulators and dead-ending only where necessary. On another line, in which a great deal of trouble was experienced from wires swinging together during high winds, the company has put in strain insulators in all spans exceeding a certain length.

The hardware used for the insulators should be of bronze or of galvanized iron or steel, should have an ample factor of safety, should be convenient to handle and to connect, should have the fewest parts possible, and should have good electrical properties so far as the distribution of potential is concerned; the suspension or strain clamp should grip securely, but yet without injury to the conductor. It is very often advisable for a power company to design certain hardware details for its individual conditions, this applying especially to the suspension clamp. There are on the market standard designs for most of the hardware which are fairly satisfactory, but it is doubtful if any of these designs for suspension clamps is entirely successful; Fig. 4 shows a design with several good features. In one case the suspension clamp was found to injure one or more of the strands of the conductor and cause failure at the point where the conductor left the clamp, although from the design it would seem that no such trouble should be experienced. This cutting was caused by a swinging of the conductor due to high winds, and was remedied by changing the form of the clamp, giving it more flare at the entrance. Some engineers recommend that the suspension clamp allow slippage of the conductor in case of line breakage, thus relieving the unbalanced pull on any tower; but it is very difficult to design a clamp which will slip at any predetermined stress, and if slippage does occur line repairs are rendered more laborious.

Spans for tower lines vary from 500 feet up to extraordinary spans of one mile or so, the average spacing giving seven to eight towers to the mile. A classic example of a long span is that of the Pacific Gas & Electric Company crossing Carquinez Straits near San Francisco, which is about 4,400 feet in length, and consists of $\frac{7}{8}$ -inch plow steel cables, giving a 200-foot clearance above the water for the purpose of navigation.

It is usually the intention to sag copper wire so that under assumed extremely unfavorable condition a stress of about 30,000 pounds, or somewhat less than the elastic limit of the material, will be produced in the conductors. The Southern Pacific Company specifies a maximum stress of 0.3 the ultimate strength of

the material. In practice, the correct sag of conductors is sometimes determined by means of a transit or level, sometimes by means of a dynamometer, and sometimes merely by eye. The average line foreman has a contempt for sag curves, believing that the best results can be obtained by the last-named method, and it is often true that after careful field and office engineering a good superintendent can materially improve conditions, making changes dictated by experience and judgment. It is the best practice, however, as soon as the profile of the projected line is obtained, to spot the tower positions and draw the line profile, using sag curves for this purpose. Sag computations should be made not only for spans having an equal elevation at the two ends, but also for unequal elevations, as in rough countries computations covering only the former will not apply. Care should also be taken that no actual uplift occurs at points where towers are placed, as corrections are not infrequently required to be made in such instances after the line has been built.

The formula most commonly employed in plotting sag curves is that founded on the equation of the parabola, and it commonly gives results of sufficient accuracy. For extreme cases, however, it is found that the error is somewhat too great, and formulæ founded on the catenary, a curve which the conductor most closely follows, should be used. Convenient formulæ and curves plotted therefrom have been drawn up by Pender and published in the *Electrical World*.

It is impossible commercially to design and build a transmission line with ample factor of safety for the most extreme conditions, and the best that can be done is to provide for the average severe conditions. For instance, sleet has been known to collect on the conductors to an outside diameter of 5 inches, and such contingencies cannot be provided against.

The greatest care should be exercised in all points of design of a transmission line, and also in the general plan and details of the erection work, especially in connection with the handling of the cable. Most jobs are rushed to completion with more regard to dispatch than to good workmanship, and annoying and expensive failures of the resulting lines are often caused by injury to the conductors during the process of stringing, or by lack of attention to the mechanical details of erection. Field inspection is seldom as thorough as is advisable.

The closest attention should also be given that the anchorages are sufficient to develop the full strength of the tower. In certain cases this may be accomplished without concrete, where the

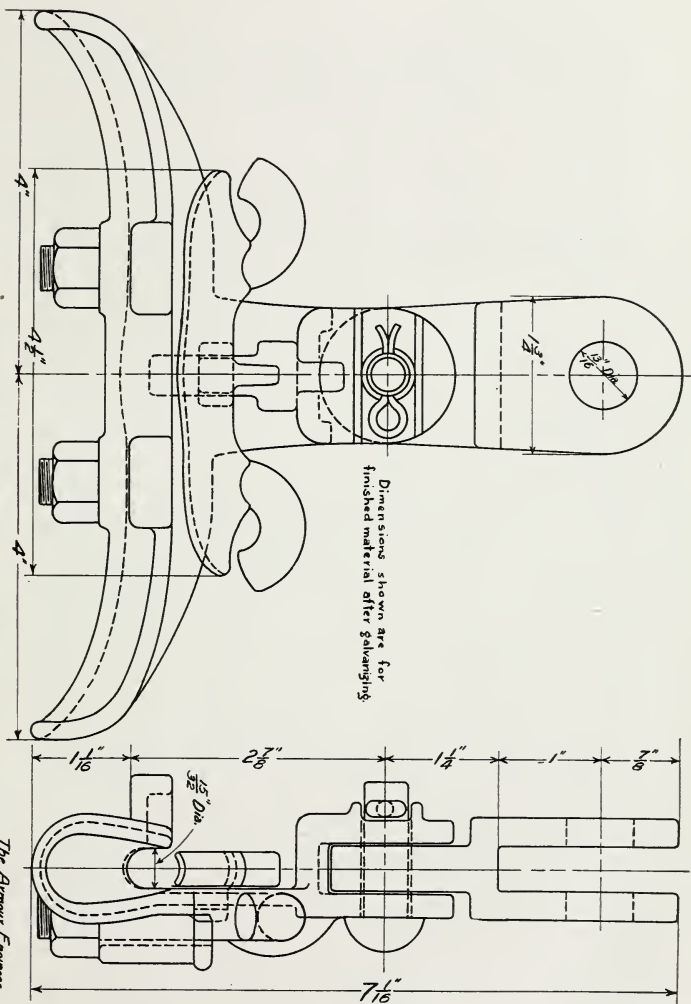


FIG. 4. Insulator Suspension Clamp Assembly.

soil is permanently hard or rocky, the anchors large, the holes well made, and back-filling and tamping thoroughly well done. In some cases, however, the soil is apparently good at certain seasons, but becomes treacherous at others; in general, concrete anchorages are desirable for a tower line.

There are many mechanical as well as electrical problems yet to be solved in connection with the design and erection of transmission lines. For instance, engineers are not yet at one as to whether strain insulators shall be employed liberally in a line, or whether they shall be used only where absolutely required. Although the general behavior of the type of insulators used in existing lines is pretty well known, yet there are a great many details of design and practice still to be worked out, such as the safeguarding of line insulators from high and low frequency surges caused by internal or external lightning. It is practically certain that transmission voltages will be increased from time to time, but yet, as observed in a recent paper before the A. I. E. E., care should be exercised in taking these forward steps, and extremely high voltages used only where commercially necessary.

It is recognized that absolute continuity of service is practically impossible over a single high tension line, and any reports to the contrary must be looked upon with suspicion. It is always desirable, when the magnitude of the project warrants it, to provide a duplicate line, although it is not in general necessary that this second line be on separate towers or along a separate right of way. This separation is desirable in case of mechanical accident to the towers or in case of severe storms, but the usual cases of trouble are such that one line only of a pair on two-circuit towers is affected.

One of the first high tension transmission lines on steel towers was that constructed by the Guanajuato Power & Electric Company in Mexico, which used what were practically windmill towers. This line was a distinct success, and at the present time it is difficult to make an accurate count of the steel tower transmission lines in the country. It seems probable that the general design of such lines has been standardized in many respects, but it is not safe to predict in this matter, on account of the rapid advance in various branches of electrical design and practice.

A NEW VOLUMETRIC METHOD FOR TIN.†

BY W. W. PATRICK, CH. E., AND
G. C. WILSNACK, CH. E.*

Numerous methods for the determination of tin have been tried out in this laboratory with various degrees of success. Gravimetric methods giving results of the required accuracy are too lengthy and tedious for ordinary use in laboratories where it is required to complete a large number of determinations in a short time. Shorter schemes, such as weighing the combined oxides of antimony and tin, determining antimony in a separate sample, and calculating tin by difference, cannot be used for alloys containing lead, copper, or numerous other metals which are to be found in some commercial alloys, unless the amount of these impurities contaminating the oxides be determined and taken into consideration.

The volumetric methods proved to be rather unsatisfactory, especially if the titrating solution was standardized against a standard reducing solution in preference to C. P. tin. The authors found that determinations on quantities as small as 5 per cent were unreliable, and that on high percentages it was almost impossible to obtain consistently accurate results even if the oxidizing solution was standardized against an equivalent amount of metal treated in an exactly similar manner.

Endeavoring to overcome these difficulties, the following method was finally adopted. The results obtained are consistent and correct to within 0.2 per cent on amounts of 50 per cent or over and considerably more accurate on smaller percentages. As large percentages of copper, lead, nickel, and perhaps other metals not experimented with, interfere, it has been found expedient to modify the method somewhat in the presence of these elements. Both determinations will be described.

Regular Method.

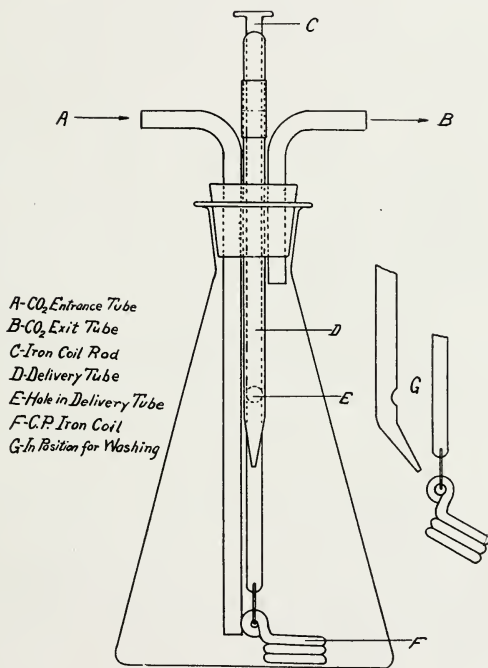
The following scheme of analysis is available where no more than 5 per cent of either lead or copper is present in the alloy. Where the percentages of these elements exceed this limit a modification of the method is necessary.

Place an amount of sample corresponding to 0.5 gram or less of tin in a 500 cc. Jena Erlenmeyer flask and add 0.15 gram

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C. P. metallic antimony if as much or more is not already present in the alloy. If the sample contains less than this amount it is necessary to make up the deficiency. Add 10 cc. of concentrated sulphuric acid and heat to effect solution. Remove from the hot plate and cool. Dilute the cold sulphuric acid solution with 10 cc. of water, add 60 cc. of concentrated hydrochloric acid, and then 40 cc. more of water. Prepare a four-hole rubber stopper that fits the neck of the flask. Through one hole pass a glass tube bent at right angles reaching to the bottom of the flask and through the hole diagonally opposite insert another tube bent in a similar manner but extending only a short distance below the bottom of the stopper. Through the third hole pass a long thin glass rod fitted with a 2-inch piece of platinum wire. This rod should fit rather snugly without, however, giving any difficulty to the operator in raising or lowering it during the determination. The platinum wire is now bent into the shape of a hook and a piece of very nearly C. P. iron wire attached. Swedish iron in plates of $\frac{1}{8}$ -inch thickness cut into strips of $\frac{1}{8}$ -inch in width and four inches in length, curled up in the form of a spiral, will suit the purpose well. Through the fourth hole pass a $\frac{1}{2}$ -inch tube 4 inches long and drawn out at the lower end to an opening small enough to enable the operator to introduce iodine solution in sufficiently small quantities to obtain the starch iodide reaction within one drop of titrating solution. The tapered end is bent slightly in the direction of the submerged wire for the purpose of conducting a stream of water to free the iron from adhering tin solution after it has been withdrawn from the liquid. This delivery tube should also be provided with a $\frac{1}{4}$ -inch hole about $\frac{3}{4}$ -inch above the lower opening to afford a means of escape for the carbon dioxide gas which is being rapidly introduced during the titration. A carbon dioxide generator is connected to the long tube while a piece of rubber tubing connects the short tube opposite to a 100 cc. pipette which dips into a reservoir of water. This automatically prevents any air from entering the system when a partial vacuum is formed in the flask during the determination, which cannot be taken care of by the entering carbon dioxide gas. Having attached the iron to the platinum wire, the rubber stopper is firmly placed in position in the neck of the flask and the rod lowered so that the spiral of wire rests on the bottom of the flask. The generator and water seal are attached as previously described, a cap is placed over the opening of the large delivery tube and a rapid stream of carbon dioxide gas passed through the system. After a few minutes it may safely be assumed that

Volumetric Tin Apparatus

all of the air is expelled from the flask, whereupon heat is applied and the contents permitted to boil for 25 minutes. The solution when first placed in the flask appears a deep yellow or orange, depending, of course, upon the constituents present, but shortly before commencing to boil it becomes colorless and finally black, due to the liberated metallic antimony. After the reduction is complete, remove the burner, plunge the flask into a large container of cold water and allow to remain until thoroughly cold. The iron wire is then raised to a position directly below the end of the delivery tube. The cap of this tube is then removed and with all possible haste a stream of cold *freshly boiled* water permitted to play upon the spiral to free it from any adhering tin solution, after which the wire is raised so that the titrating solution will not come in contact with it. Freshly prepared starch is added and, without interrupting the passage of gas, standard iodine solution introduced into the flask as fast as the burette will permit. When near the end point, which is indicated by the reluctant disappearance of the blue, the titration can be carried on very slowly until completed. The blue of the starch iodide is not permanent, disappearing after a minute or two, which fact does not, however, detract from the accuracy of the determination.

It is not to be understood that the tin is completely reduced by the direct action of the iron alone, neither will the addition of pulverized metallic antimony bring about the desired result. However, this metal as deposited is in a state where its chemical activity is at a maximum, thus enabling it to fully complete the reduction.

Standardize the sodium thiosulphate, which serves to determine the strength of the iodine solution, very carefully against a bichromate or permanganate solution of known strength. It is essential that the utmost accuracy be employed in the above standardization, since 0.1 cc. more or less of a $N/10$ oxidizing solution makes a considerable difference in the ultimate tin value of the iodine. It has been found advisable in finding the normality of a freshly prepared iodine solution to check the theoretical standardization against C. P. tin.

Modified Method.

A modified method is used when 5 per cent or more of copper or lead, or any other interfering element, is present in the specimen to be analyzed.

Place 0.5 to 1 gram of sample in a small casserole and add if necessary 0.15 gram of antimony as in the regular method. Cover the sample with 8-10 cc. of concentrated nitric acid and evaporate

to dryness. It is advisable in order to facilitate the subsequent filtration to bake strongly for about 15 minutes. Cool and add 20 cc. of 1-1 nitric acid, and, after breaking up the lumps with a stirring rod, filter and wash several times with hot water. If the baking has been conducted properly no traces of oxides will be discernible in the filtrate. The precipitate with the filter paper is then placed in a 500 cc. Jena Erlenmeyer flask and treated with 20 cc. of concentrated sulphuric acid and 2 grams of potassium sulphate. Place the flask on a piece of asbestos over a medium hot burner and heat carefully till the first violent reaction is over, after which the heat can be increased. Towards the end of the oxidizing operation, while the liquid is still black, however, from the free carbon present, the flask and contents should be cooled and the sides of the container washed down with a stream of water. The particles adhering so firmly to the wall of the flask that the water does not loosen them should be brought back into the main solution with the aid of a "policeman." The removal of the carbon should by no means be hastened by the addition of an oxidizing agent, since this will cause the antimony to assume the pentavalent form, which must be avoided. The addition of the water will now have a tendency to again cause frothing when the heat is applied, making it necessary to conduct this operation very carefully. From 2-2½ hours are usually required, depending upon the intensity of heat employed, to rid the solution completely of the carbon. Cool, introduce the required amount of water, but add only 45 cc. of hydrochloric acid instead of 60 cc. as in the regular method.

If very large percentages of antimony are present, enough to obscure the end point obtained with the starch solution, it is well to treat in the usual manner up to the point where the metallic antimony separates out. The solution should then be rapidly cooled, filtered with suction and washed with hot water. About 0.10 gram of metallic antimony, which has previously been dissolved in a few cc. of sulphuric acid, is then added, the solution returned to the original container, and the reduction continued. The concentration of the solution after this operation should not be changed to any great extent, the additional acid introduced off-setting in a large measure the water used for washing. Antimony present up to 25 per cent will not obscure the end point, provided a good light and white background are available.

The accompanying table gives a few results obtained on mixtures containing various amounts of copper, lead and nickel as noted. These figures are fairly representative of the results

which may be obtained by the methods described in the preceding pages.

Method.	Approximate amount.			Tin taken. Gram.	Tin found. Gram.	Error. Mg.
	Copper. Gram.	Lead. Gram.	Nickel. Gram.			
Regular .....	....	....	....	0.4040	0.4038	0.2
Regular .....	....	....	....	0.0568	0.0575	0.7
Regular	0.03	....	....	0.4470	0.4478	0.8
Regular	0.05	0.05	....	0.1143	0.1153	1.0
Modified	0.25	0.30	....	0.4060	0.4065	0.5
Modified	0.03	0.66	0.03	0.1764	0.1763	0.1
Modified .....	....	0.30	0.05	0.4272	0.4261	1.1
Modified	0.15	0.80	....	0.0216	0.0214	0.2
Modified	0.08	0.80	....	0.1000	0.1000	0.0
Modified	0.50	....	....	0.4530	0.4526	0.4

GAS ENGINE OPERATING DATA.

BY DANIEL ROESCH.*

General.

The following data pertains to medium sized gas engines operating on central station loads, where reliability and continuity of service were primary factors. The question of economy of operation and low repair bills, however, followed a very close second, and the data regarding gas, water and oil consumption will be found to be fairly representative of this class of prime mover when operating under similar conditions of load.

The plant consisted of three generating units furnishing 2300-volt current for distribution in a town of 30,000 population. The load consisted of series arc lamps for street lighting, commercial lighting of stores, theaters and residences, and a small day power load of motors ranging from 15 horse power down. Two of the generators were 180 kilowatt rated output and the third one 150 kilowatt. These were each belt driven by a gas engine operating on natural gas. The 180 kilowatt generators were each driven from an 18x22, three-cylinder, vertical, enclosed crank case type gas engine and the 150 kilowatt generator was driven from a 19x25 tandem, single acting, horizontal gas engine. The vertical engines operated at a speed of 200 R. P. M., and the horizontal engine at a speed of 175 R. P. M.

The size of the generators in the case of the vertical engine sets was usually nicely balanced to the capacity of the engine, but in the case of the horizontal engine set the rated generator capacity was considerably below that which the engine could care for, even with a non-inductive load. The result was that the limiting load on this set was usually reached by overheating of the generator windings and bearings before the maximum load of the engine had been reached.

This feature was equally true of all the sets when low power factor of the load gave a heavy current without a proportional increase in kilowatts, the low power factor being caused principally by the series arc light portion of the load.

The auxiliaries in the plant consisted of motor-driven, water-circulating pumps for the engine jackets, together with reservoirs

*Class of 1904. Instructor in Experimental Engineering, Armour Institute of Technology.

to recool the water; Edison primary batteries for ignition current when starting and current supply from the exciters of the main generators for ignition purposes under normal operation; an independent air compressor, belt driven from a three horsepower gas engine, to furnish air up to 200 lbs. pressure for starting the main engines; house transformers for stepping down the 2300-volt current to 115 volts for lights and 230 volts for the motors in the power house; constant current transformers which changed the constant potential current, supplied by the generators, to 6.6 amperes constant current for the arc lamps, each constant current transformer taking care of from forty to fifty-five enclosed carbon arc lamps connected in series. These transformers were replaced during the writer's connection with this plant by eight of the more modern direct current arc lamp sets, which gave a more efficient lamp, but had the objection of giving a somewhat lower power factor to the supply circuit, *i. e.*, to the generators.

This aggravated the trouble mentioned above of having the generators loaded by a high kilovolt-ampere load but a low kilowatt load, making it impossible to load the engines to their maximum and hence cutting down on the efficiency of the plant. The direct current was obtained in these outfits by means of mercury arc rectifiers.

The switchboard was provided with all the apparatus necessary to handle the load and synchronize the generators when it was desirable to put additional units on the line. All the 2300-volt switches were immersed in oil to prevent destructive arcing when opening them. Synchronizing was done with lamps and this method proved entirely adequate because of the elasticity of the belt connection between the generator and the prime mover. If a unit was thrown on the busses when it was slightly out of step there would only be a slight flutter in the 24-inch belts and the rotating armature of the generator would get into step with very little disturbance. All generators fed to either one of two sets of bus bars and from the bus bars three double-throw oil switches closed the circuit from either set of bus bars to two commercial feeders and one arc feeder. The two commercial feeders led into different parts of the town and provided a means of keeping a part of the town in current should trouble occur on the lines. The arc feeder led to the mercury rectifier sets in the power house and from there to the various arc circuits. Each of these feeders was provided with an integrating kilowatt-hour meter, the sum of these meters showing the output of the plant at the switchboard. All outgoing circuits had lightning arresters of the

multiple-gap and resistance type. The current consumed in the power house for lighting and power was determined from time to time by checking with a small low potential watt-hour meter on the secondary side of the house transformers.

A return tubular boiler, gas fired, supplied low pressure steam for heating the building in winter and all the gas used in this boiler and for emergency gas lights in the power house passed through the station gas meter and was charged to the engines.

Operating Economy.

The table of data represents a $3\frac{1}{2}$ year record of output; gas, water and oil consumption and time of operation of the generating units.

Column No. 2 shows the monthly output in kilowatt-hours as registered by the station meters on the commercial lines, and column No. 3 the output for the arc meters. Column No. 4 is the estimate for the consumption of current in the power house. This current being taken directly from the bus bars, was not registered by the other meters. Column No. 5 is the total number of kilowatt-hours generated at the switchboard in the plant. Column No. 6 shows the total monthly gas consumption of the plant, including gas used for heating the building and for a few emergency lights about the place. The economies of the engines are of course better than indicated for all months in which artificial heat was required. There was, however, no simple way in which this correction could be made with any degree of accuracy. No correction was made for temperature and pressure variation from standard conditions for the gas. The volume of gas passing the meter was the basis for figuring the cost of the gas. No variation in temperature or pressure of the gas or accuracy of the meter was used to arrive at this expense, so that as far as influencing costs there would be no object in noting these correction factors.

The total number of cubic feet of gas consumed per month divided by the total output in kilowatt-hours is calculated under column No. 7 and represents the gas consumption per kilowatt-hour at the switchboard.

Column No. 8 shows the total monthly consumption of water used from the city mains and column No. 9 the average monthly consumption of fresh water per kilowatt-hour generated.

The load factor was calculated in the usual way of dividing the total output by the output if all units were operating at rated load continuously, in column No. 10. Probably a more logical method is to divide the total output by the output generated if the units

were operated at full load whenever it was necessary to have them running. This load factor is given in column No. 11. Columns No. 12 to No. 15, inclusive, show the engine and dynamo oil consumption for each month after these records were started.

A record was kept of the time of operation of each unit and is shown for each of the units under columns No. 16, No. 17 and No. 18.

In order to calculate the load factor "B," column No. 11, the time in hours per month that each engine was operated was multiplied by the rated generator capacity and the three products added. This data is shown in the last four columns of the data sheet.

Notes on Operating Economy Sheet, Fig. 1.

In a plant of this character it is to be noted that the output is considerable higher during the winter months than during the summer months because of the shorter days in winter. The load was principally a lighting load.

The gas consumption per kilowatt-hour is lower under the greater outputs because of the better load factor on the units. This is shown in spite of the fact that the gas for heating during winter is charged to the engines. By comparing the gas consumption per kilowatt-hour for the different months with the corresponding load factor "B," it will be noted that the lower the load factor the greater the gas consumption.

The water cost about 60 cents per thousand cubic feet, and it will be seen that for some of the earlier months of the period shown the water bill amounts to quite an item for a plant of this size. A cooling pond was decided upon and one with earth banks and bottom was tried in May and June, 1910. The effect on the water consumption was so gratifying that this was enlarged slightly to a reservoir 50x75 feet by 6 feet deep, with concrete walls and bottom, and put in service about September, 1910. A system of twelve spray nozzles and circulating pump completed this portion of the equipment and proved to be money well invested. The nozzles used were of the adjustable kind commonly used on the end of a garden hose and when set to spray a fine mist on the pond were well adapted for this work.

Under the columns showing the total hours operated of the various units it will be noticed that engine No. 1 operated 665 hours during January, 1911, out of a possible 744, or 89.3 per cent of the elapsed time, and the following month 612 hours, or 91.1 per cent of the elapsed time. These runs represent an aver-

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MONTH	K.M. HRS. GENERATED, 1/1/1914/2/2/20				CU. FT. GAS USED			CU. FT. CITY WATER USED			LOAD FACTOR, %		OIL USED, GALS.					TOTAL HOURS OPERATED, ENGINE NO.			GENERATOR CAPACITY, K.W.HRS. BASED ON TIME OPERATED.							
	CUM.		AFC.		HOUSE		TOTAL		TOTAL		1		TOTAL		ENGINE		DYNAMO		1.		2.		3.		4.		5.	
	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.
JAN.	34200	41300		78500	2021.0	25.8	31260	0.399	22.10																			
FEB.	35200	38100		76300	1906.1	25.0	60890	0.798	22.08																			
MAR.	35000	32500		70500	1756.2	24.9	35760	0.504	19.15																			
APR.	33600	29000		65600	1608.3	24.5	68760	1.048	19.28																			
MAY.	31600	26700		61300	1526.6	24.9	109160	1.780	16.67																			
JUNE.	33900	30000		66900	1671.7	25.1	158380	2.370	17.60																			
JULY.	36000	31500		70500	1921.1	27.3	191650	2.720	18.57																			
AUG.	39600	40100		82700	2162.2	27.3	180340	2.220	22.48																			
SEPT.	42600	47600		93200	2326.5	25.0	122290	1.318	24.52	49.6	53.7	0.0609	57	0.0061	378	3.85	3.18	74500	69300	47700	183500							
OCT.	43400	49600		96000	2442.2	27.6	59200	0.618	26.08	49.7	46	0.0576	50	0.0052	381	3.94	3.65	67500	70800	64700	193100							
NOV.	49600	53800		106400	2821.8	26.5	43000	0.404	28.20	51.1	464	0.00436	46	0.0044	408	3.90	4.33	73400	70800	64700	208300							
DEC.	43200	52700		98900	2696.8	27.3	24970	0.252	26.05	42.4	424	0.00428	42	0.0043	382	3.91	4.21	67700	70400	63200	201300							
JAN.	31100	31200		65300	2187.0	33.5	14430	0.221	18.55	43.5	309	0.00473	31	0.0047	363	2.93	4.20	66300	49100	36000	150400							
FEB.	35400	43400		81800	2675.2	32.7	30680	0.276	21.53	41.0	309	0.00378	31	0.0038	422	4.70	1.72	73500	73500	64700	186200							
MAR.	33500	35800		72300	2153.9	29.8	27140	0.376	19.67	41.3	181	0.00250	18	0.0025	395	3.44	2.81	71000	61900	42200	175100							
APR.	32200	32300		67500	1928.1	28.5	37480	0.3536	17.78	44.8	210	0.00311	21	0.0031	277	3.83	2.62	49800	69000	38300	158700							
MAY.	31400	29200		63600	1682.2	27.5	67960	1.048	17.29	36.3	268	0.0422	27	0.0042	326	6.24	2.71	52700	112100	40700	175300							
JUNE.	33500	29500		66000	1818.6	27.6	89950	1.363	17.38	37.6	314	0.00476	31	0.0048	450	4.18	2.57	63000	73200	37700	175700							
JULY.	33700	38400		74100	1902.4	25.7	92610	1.249	19.35	44.1	230	0.00311	23	0.0031	368	3.91	2.86	66200	70400	42900	179500							
AUG.	38800	39900		81700	2446.8	25.1	92950	1.161	22.20	44.1	345	0.00423	35	0.0042	401	3.87	2.92	72200	69600	40900	185700							
SEPT.	44500	48200		96100	2465.8	25.7	72220	0.752	25.32	46.2	376	0.00391	38	0.0039	448	4.00	3.74	80500	72100	56100	208600							
OCT.	46900	49700		98200	2527.6	25.8	60530	0.618	26.68	47.4	370	0.00377	37	0.0037	445	3.77	3.98	80000	67800	57900	202500							
NOV.	55200	52500		110700	2652.3	24.1	44030	0.399	23.10	47.7	377	0.00341	38	0.0034	459	4.10	4.31	87300	73800	44500	222900							
DEC.	50700	51100		104800	2785.4	26.6	28930	0.276	27.53	48.4	340	0.00335	34	0.0033	477	4.91	4.00	84300	83400	65000	216200							
JAN.	35700	41100		79800	2131.3	26.8	28530	0.282	23.30	46.7	368	0.00443	36	0.0045	364	4.18	3.45	65500	77800	51800	196100							
FEB.	38200	40900		82100	2320.6	28.2	32330	0.393	21.66	40.9	339	0.00413	34	0.0041	405	4.00	3.40	73200	72400	57400	201300							
MAR.	33600	34000		70600	2250.4	31.9	45240	0.640	19.21	86.6	302	0.00428	30	0.0043	398	4.39	2.87	71600	79000	43100	193700							
APR.	29200	30400		62600	2185.5	34.9	7040	0.112	16.52	30.9	377	0.00602	38	0.0060	493	4.30	2.45	88600	77200	36700	202700							
MAY.	25400	25300		53700	2081.6	38.8	10470	0.195	14.57	30.7	368	0.00667	36	0.0067	373	4.04	2.32	67100	72600	34800	174500							
JUNE.	28100	30500		61600	2243.0	36.4	83740	1.360	16.26	33.6	439	0.00712	44	0.0071	526	4.25	2.28	71200	78200	34200	183600							
JULY.	27800	30500		61300	2278.1	37.2	58710	0.958	16.18	32.5	399	0.00534	34	0.0053	431	3.83	2.79	72500	68900	41700	183300							
AUG.	33500	35200		71700	2192.3	30.6	42070	0.576	19.48	37.6	537	0.00752	54	0.0075	394	4.08	3.08	70200	73400	46300	190600							
SEPT.	43100	40700		86800	2696.7	31.0	10850	0.125	22.88	35.8	465	0.0586	47	0.0585	432	4.13	3.57	81300	74900	53700	219400							
OCT.	47900	38300		89200	2788.5	33.4	2020	0.037	24.22	42.8	530	0.00574	53	0.0057	432	4.37	3.57	77600	73500	53500	209700							
NOV.	54500	41600		99100	3226.4	32.5	6460	0.065	26.45	48.4	507	0.00512	52	0.0051	576	4.06	2.67	92800	73000	41000	205700							
DEC.	47400	49600		100000	3297.4	29.7	5070	0.057	26.30	44.7	485	0.00485	49	0.0049	665	4.46	2.79	117800	62300	41000	224000							
JAN.	38400	44400		85800	2937.4	34.1	1960	0.023	25.00	43.1	443	0.00491	40	0.0049	612	3.05	2.32	109800	57300	34800	199600							
FEB.	36600	43600		83200	3005.3	36.7	4430	0.063	21.95	39.7	379	0.00453	38	0.0045	418	5.70	1.60	80500	10400	24900	208700							
MAR.	33300	37100		73400	2282.3	31.1	1370	0.019	19.92	38.1	260	0.00355	26	0.0036	504	4.91	91	70600	88300	32600	192500							
APR.	30500	33500		67000	1996.8	29.8	24780	0.369	17.66	34.8	333	0.00477	33	0.0048	509	5.01	73	94500	90000	10700	192400							
MAY.	38600	36100		71700	2001.2	27.9	47900	0.668	19.48	39.6	343	0.00477	34	0.0048	479	4.87	56	81500	86500	8000	181000							

A - BASED ON ALL ENGINES OPERATING FULL LOAD CONTINUOUSLY.
 B - BASED ON ENGINES OPERATING FULL LOAD WHEN NEEDED.

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age of close to 22 hours per day with no exceptional wear and tear on the units.

Under these conditions of operating one unit at full load would have developed more kilowatt-hours than the total output of the plant. Under the actual load conditions of the plant, *i. e.*, low day load with heavy peak during the evening, it was necessary to have three times this capacity operating every night in the week, with the exception of Sunday night.

Load Curves, Figs. 2 and 3.

The characteristic load curves for winter and summer load are shown in Fig. 2. The curve AA shows the loads on the switch-board instruments during 24 hours during winter. The dotted line A' shows the available power that is operating, the vertical portions of this curve indicating the cutting in or out of units to suit the load.

The curve BB indicates the summer load and shows a much shorter peak than curve AA, accounting for the smaller kilowatt-hour output during the summer months.

In reference to the winter load and capacity curves it will be noted that the area under AA represents the output at the switch-board and the area under A' represents the output if the units were fully loaded while operating. The former corresponds to column No. 5 in the data sheet, Fig. 1, and the latter to column No. 22. The area under AA divided by the area under A represents the load factor, column No. 11, Fig. 1.

The lowest load factor on the plant occurred during the day, and as this period was several hours longer in summer than in winter the monthly load factors show lower at this time of the year. Largely because of this the fuel consumption per kilowatt-hour was higher for the summer months in almost each instance.

A characteristic load curve from a similar plant in Pittsburg is shown in Fig. 3. This plant had two units of the size indicated by curve A' and received what additional power was required for its peak from a neighboring steam plant. In addition to this the day and night power load was greater than in Plant A, and resulted in a higher load factor on the plant and better economy.

The characteristic Pittsburg morning fog is shown by the morning peak indicated between 6 and 10 A. M., these morning peaks being sometimes twice the height indicated. An interesting human trait is also shown by this morning peak curve, namely, people will turn on the lights as soon as needed, but will not turn them off for some time after they are through with them. Hence

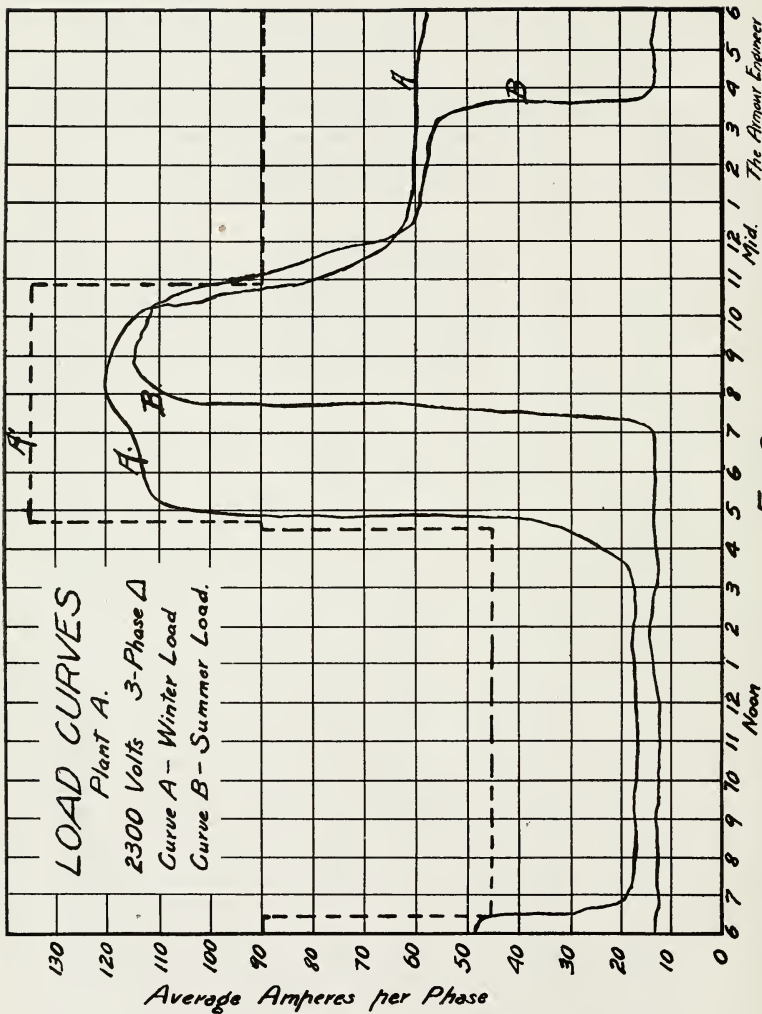
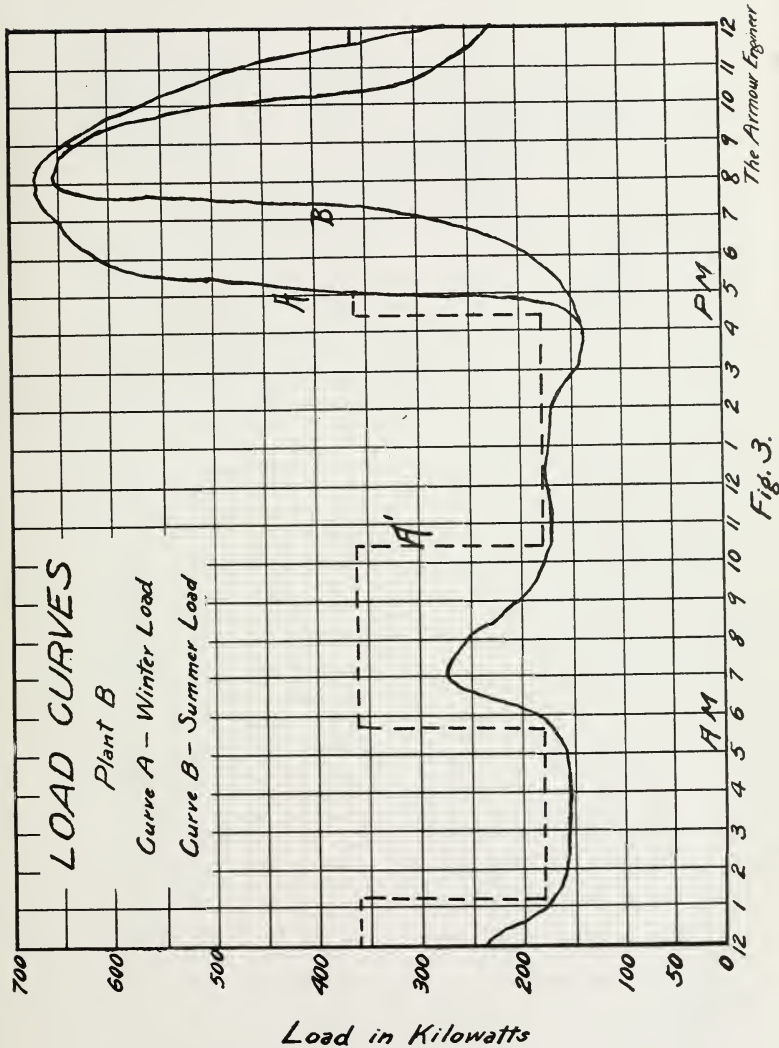


Fig. 2

Noon

Mid.

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the sharp upward slope of the curve and the gradual downward slope. The upward slope would sometimes be practically a vertical line and allow of only three to five minutes to get an additional unit on the line.

Curve B indicates the summer load curve for the same plant.

Summary on Operating Economy.

Plant A.* Figs. 1 and 2.

1. Gas per kilowatt-hour at switchboard (41 months),
cubic feet 28.85
2. Load factor, based on engines fully loaded when
operating (41 months), per cent.....43.2
3. Over-all thermal efficiency from gas meter to switch-
board (41 months), per cent.....12.45
4. Over-all thermal efficiency from gas meter to engine
brake horsepower (41 months), per cent.....14.92
5. City water per kilowatt-hour at switchboard (41
months), cubic feet 0.653
6. Engine oil per kilowatt-hour at switchboard (33
months), gallons 0.00463
7. Valve and dynamo oil per kilowatt-hour at switch-
board (33 months), gallons..... 0.046
8. Over-all thermal efficiency from gas meter to switch-
board (best month), per cent.....14.68
9. Over-all thermal efficiency from gas meter to engine
brake horsepower (best month), per cent.....17.55

*Items No. 3, 4, 8 and 9 based on 950 B. t. u. per cubic feet of gas. Items No. 4 and 9 based on 1 kilowatt-hour equals 3412 B. t. u., and generator and belt efficiencies 88 and 95 per cent respectively.

Plant B.* Fig. 3.

1. Gas per kilowatt-hour at switchboard (24 hours),
cubic feet 17.80
2. Load factor, based on engines fully loaded when
operating (24 hours) approximately, per cent...80.00
3. Over-all thermal efficiency from gas meter to switch-
board (24 hours), per cent.....20.20
4. Over-all thermal efficiency from gas meter to engine
brake horsepower (24 hours), per cent.....21.95

*Items No. 3 and 4 based on 950 B. t. u. per cubic feet of gas. Item No. 4 based on 92 per cent generator efficiency. (Direct-connected units.)

SOME PRACTICAL CONSIDERATIONS IN THE FABRICATION OF STEEL BRIDGES.

BY R. W. JOHNSON.*

The fabrication of steel bridges covers too wide and extensive a field to write with any great thoroughness upon it in an article necessarily limited in length. At the very beginning we are in difficulties as to how to present our subject, for no two bridge concerns have the same system of putting work through their shops, due either to individual preferences of shop heads or to the layout and equipment of the shops.

Let us first consider shop manufacture in general. The steel bridge contractor has successfully bid on a bridge or a number of bridges to be fabricated according to specifications mentioned in the call for bids and according to drawings submitted. If the purchaser is to do his own erecting the price is usually on a pound basis f. o. b. on cars. If the contractor is to do the erecting the price may be on a pound basis or on a lump sum price complete and erected. Some purchasers submit only the design and the contractor makes the detailed drawings. The great advantage in this is the chance it gives to the contractor to make the fabrication of the details conform most economically to his shop practice and equipment. Other buyers prepare not only the designs, but also the shop drawings. Drawings thus made are prepared more carefully and give fuller information than those gotten out by the contractor, who is apt to crowd his draftsmen to get the work into the shop. Also drawings of the latter type are all prepared under certain standards and, when filed, form a uniform record. Furthermore, no time is lost in getting drawings approved, which in many instances is a long and tedious process.

The drawings checked for shop use are now taken to the templet shop, where practically everything is laid out on wood or cardboard. Templets require a good grade of timber, thoroughly dried and free from knots. Recently, however, prices on timber have advanced so high that it is cheaper to lay out the smaller details on a heavy cardboard. Some shops even use the wooden templets over by planing off the old marks and plugging up the holes for laying out the rivet spacing. Templets for use with some multiple punches have steel pegs to indicate the rivet spacing in place of the holes bored for inserting the laying out punches

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in the ordinary templet. After the templet has served its purpose these pegs can be withdrawn and spaced over again in the same piece of wood for other work. Whenever there is any doubt about connections fitting, the templets are put together, if it is practical to do so, before they are sent to the laying out shop. Camber for a girder is usually framed into the templet for laying out the web plate.

The templets, after being made by one person and checked by another, are taken to the laying out shop, where each templet is placed on the proper piece of material, clamped in position and the rivet holes marked off by inserting a small center punch in each hole of the templet and striking it a sharp blow, so as to mark the metal. Edges to be sheared are marked by dotted lines made with the laying out punches. As soon as the templet is removed, the sheet number of the drawing, the contract number, and the mark of the member to which the piece belongs is copied from the templet and marked on with white lead. The practice nowadays is to reduce laying out to a minimum, and this has been accomplished by using multiple punches, which punch the main angles and plates, providing the latter are not too wide to pass through the punch, and by "punching to a templet" the detail plates. These plates have first been sheared to the proper shape, then the templet is placed in its proper position and the plate is punched through the holes of the templet. Should there be a number of plates of one kind, a sheet-iron templet is made, as one made of cardboard would soon wear out. Material such as crimped stiffener angles, bent plates and bent angles are always laid out after the crimping and bending have been done.

After being laid out the material is ready to be punched. Some specifications, especially for railroad work, require that the holes be sub-punched three-sixteenths of an inch smaller than the nominal diameter of the rivet. For seven-eighths-inch diameter rivets this means holes sub-punched eleven-sixteenths of an inch diameter. There is a general rule which works out fairly well in practice, that the thickness of the piece to be punched should not exceed the diameter of the punch. It is difficult to punch metal over three-quarters of an inch in thickness with a punch eleven-sixteenths of an inch in diameter, owing to the tendency of the punch to bend a little as it punches successive holes, and finally to break. This tendency to bend increases, the harder the metal, and sometimes the hardness is so great that the punch cannot even force its way through without bending or splintering to pieces.

The most up-to-date shops employ multiple punches, which can punch from one to thirty or more holes at one time. In general

a multiple punch consists of a row of punches mounted on a heavy frame and so connected to levers that any combination can be operated at one time. On one side of the frame is a row of skids with rollers placed on them, on which the material to be punched is laid. On the other side of the frame is a long table equipped with a carriage, which can be operated from one end to the other of the table. The material to be punched is placed on the skids with one end just ready to pass under the punches. Then the carriage is moved down near to the frame, and by means of clamps the carriage is secured to the plates or angles to be punched. On the table carrying the carriage the templet is clamped rigidly, the rivet spacing being indicated by steel pegs, with each of which an arm from the carriage comes in contact in succession as the carriage moves along the table, pulling the material under the punch and stopping while each set of holes is being punched. Flange angles are always punched in pairs, some machines taking two or more pairs at a time. Narrow web plates to the number of two or three can be punched at one time. Wide web plates will not pass through such a punch unless it is unusually large, and then will ordinarily be punched, so that no camber will be given to the finished girder. There are, however, machines made taking wide plates, which have an adjustable table moving the plate, so as to raise the rivet spacing toward the center of the web, and thus give the girder camber when it is fitted together.

All material, when punched, has a tendency to elongate and the longer and the heavier the piece the more noticeable it is. Material punched on a multiple punch will have the distance between each hole exactly right, the elongation being between the last hole and the edge of the piece. Material laid out and then punched will have a small portion of the elongation between each hole. For these reasons material for a certain section punched on different sets of punches, as just mentioned, will not fit together well and cases have even arisen where the holes were badly slotted after being reamed.

The different pieces going to make up a structural section are now brought together to be assembled. Here again holes punched eleven-sixteenths of an inch in diameter are troublesome. Punching cannot be done so accurately that a number of pieces will fit together and allow the use of five-eighths-inch drift pins and bolts in fitting up. Instead, one-half-inch drift pins and bolts must be used, and these are too light to draw up heavy work properly and quickly. For this and another reason—which will be discussed later on—the heaviest work should have the rivet holes punched thirteen-sixteenths of an inch in diameter and reamed to one

and one-sixteenth of an inch diameter for one-inch rivets. In assembling, care is taken to put in enough bolts to draw the work close together, and pains are taken to see that those parts requiring a tight fit do bear before the work goes to the reaming department.

Reaming in modern shops is generally done with high-tempered steel drills running at a high rate of speed. All the open holes are reamed first, then enough seven-eighths-inch diameter bolts are put in to hold the work together, the small bolts and drift pins are removed, and the reaming is completed. All holes to be reamed to a templet are marked, so as not to be included in the general reaming.

In riveting it is the general requirement and practice to drive as many rivets as is possible with the high-pressure machine riveters and leave as few as possible for the hand pneumatic hammers. For designing and detailing rivets are classed as shop and field. This is not proper, because many rivets are driven by hand hammers in the shop under exactly the same conditions as obtain in the field. A better designation would be machine and hand rivets.

The rule in designing that the grip of the rivet should not exceed four diameters of the rivet is a good one to follow, not only because of the bending stresses set up in a long rivet, but also because it is impossible to upset a long rivet for its entire length. The shank of the rivet under each head will be upset for a short distance, but the center will remain practically unchanged. For heavy work one-inch rivets should be used, for the increased stock will insure a better chance of upsetting the entire grip of the rivet.

For heating rivets coal, coke, gas and oil are used, the latter more extensively than any of the others. Coke, gas and oil are apt to heat the rivets too hot and burn them if not watched carefully. Hard coal in the form of pea coal gives the best results of any of the above heating agencies, and properly used will heat rivets which, when cool, will show no signs of scaling.

After the work passes from the machine riveters it is ready to be finished up. Rivets not accessible to the larger machines are now driven by hand, rough edges are chipped smooth, and milling and templet reaming are completed, if required. Milling is usually specified to be to exact length. Practically it is best to mill stringers scant a thirty-second of an inch, for the stringers will build up at the floor beam connections, and when slightly short, will go together much more easily.

Templet reaming is sometimes specified to be done through templets one-inch in thickness, in which the holes have been

accurately centered and drilled. This is objectionable, first to the contractor on account of the amount of metal used up with such heavy templets and the amount of weight to move around, and second, to the inspector, who has hard work to get the contractor to get out new templets when the old ones have become worn and slotted through repeated use. The best templet is made of one-quarter or three-eighths-inch metal, with holes accurately set and large enough for holding hardened steel bushings, which last a very long time.

The work is now ready for the final inspection by the purchaser's inspector, who checks it over, and if acceptable, stamps it with his private mark. The larger shops have their own inspectors, who stay with the work from the beginning to the end. Under such circumstances errors are not likely to get through. In small shops the only inspection, until it reaches the purchaser's inspector, is the little it gets from the various foremen. With such methods many errors creep in which are expensive to correct when found in the final inspection.

The work is now painted, preparatory to being weighed and loaded for shipment, though some shops weigh the pieces as they pass from the finishing shop to the paint yard. Painting is usually the poorest work done in a bridge shop. The help is the most poorly paid and the least intelligent. Generally they are hurried to the utmost, for a car is right at hand ready for loading. With such conditions it is difficult to get the material cleaned off and the paint brushed out to a uniform thickness covering each entire rivet head and all crevices. Unless the paint is brushed around rivet heads, small portions of the steel will be left exposed and will soon rust, causing the paint to start to peel.

Painting in the fitting-up department is even poorer, for "fitter ups" do not even pretend to be painters. They will take paint from the top of a barrel without bothering to stir it up, and as a result get mostly oil. They are not apt to spread the paint out by proper brushing. However, paint applied to two surfaces coming in contact with each other is largely burnt out when the riveting is being done, leaving enough paint, though, to fill interstices and keep out water.

Most specifications call for parts which will be inaccessible after erection to be given two coats of paint, and then make no distinction in color for the two coats. For this reason it is hard to get this second coat put on satisfactorily. Take the tops of stringers for instance. There will most likely be a lot of these to one job and the contractor cannot afford to keep them spread out while the first coat dries, but must either stack them up or

load them for shipment as soon as the first coat is applied. Then with the second coat the same color as the first, it is impossible for a painter, after several hours' work, to see that he covers the surface uniformly. Also, it is not possible for an inspector to see that the second coat is consistently applied unless he is at hand to see each piece painted, which is a physical impossibility with his other work to attend to. The best plan to get this second coat put on would be to specify a certain kind of paint to be applied to all surfaces coming in contact with each other, and to all surfaces inaccessible after erection, the same to be applied while fitting up. Then for the final shop coat a paint of an entirely different color should be specified and used.

For work of ordinary weight one gallon of an oxide or graphite paint will cover two and one-half to three tons of steel as an assembling and shop coat.

In conclusion a few interesting facts come up in putting truss and plate girder spans through a shop. The truss spans built at the present time, particularly those of short and medium lengths, are mostly made with riveted connections, because such a span is stiffer than a pin-connected one. The best specifications call for all trusses to be completely assembled in the shop, the sub-punched connection holes to be reamed, and the various pieces to be match-marked before taking apart. Many contractors object to this complete assembling, so some specifications are modified. Thus, when there are two or more similar spans in one bridge, one truss is completely assembled and reamed. If the holes are good at all the connections, the hip joints, where the top chord and end posts bear on each other and the splices of the top chord are only assembled, while the connections of the remaining joints are reamed to templates.

In reaming a truss after it has been put together, either as a whole or in sections, drills with long shanks are used, which will pass through and ream out both the upper and under side of the various members. Should the posts of the truss connect to floor beams on each side, the truss is blocked up high enough so as to ream the floor beam connections through templates from the under side.

Methods of handling girder work vary widely in the various shops. Some assemble the top and bottom chords; that is, the flange angles and cover plates first, putting in filler plates to keep the proper space for the web plate. Then the holes through the outstanding legs of the flange angles and through the cover plates are reamed, and one of the flange angles is riveted to the cover

plates. Now the top and bottom chords are laid on the assembling skids, the loose flange angles are removed, the web plate laid in place and the loose angles of the flanges bolted in place. The girder is raised in an upright position and the stiffener angles and plates are fitted in place. The stiffener angles are sheared long and are ground, so as to fit tightly between the flanges. Filler plates under the end stiffener angles in the best kind of girder work are required to bear on the tops of the web legs of the bottom flange angles, so as to give greater effectiveness to the stiffener. In this connection it might be well to say that no end stiffener angle should be placed at the very end of the girder, but at least an inch from the end. This because of the fact that the ends of the flange angles have been rounded off in shearing and furnish no straight surface for effective stiffener angle bearing.

As a rule the outstanding leg only of a stiffener angle bears tightly against the flange angles. The web leg is usually "bevel sheared," and while it should have a neat fit does not bear. For an intermediate stiffener angle, light and crimped, the bearing of this leg is of no great value, because of the offset due to crimping and the fact that bearing would only be along a line. For a heavy end stiffener, which is not usually crimped, the web leg will have enough surface for bearing to justify that it be ground to fit or planed in a shaper with a tool ground to correspond to the fillet of the flange angle.

After the girder has been completely assembled it is sent to be reamed, and then completely riveted. The objection to assembling the chords first and riveting one side is because, through carelessness or variations in rolling, the loose filler plates put in to keep the flange angles spaced for the web are sometimes not of the same thickness as the web, and when the web is put in and the parts bolted tightly together, the holes in the flange angle and the cover plates do not match up. This causes either a crooked row or rows of rivets, or may be so much out that the holes have to be re-reamed.

Some shops do not handle girders this way, but fit them up, leaving off the cover plates, and then, when the web has been reamed and riveted, drop them in pits, so that the uppermost flanges come just below the reaming and riveting machines. The cover plates are now put on, reamed and riveted. This is by far the best way for all concerned. The purchaser gets a neat looking job, with flange rivets in straight rows, and the contractor saves much rehandling and extra work.

Some shops handle the girders upright from the very start. The bottom flange is clamped to the fitting up skids, the web is inserted, the top flange put on and the stiffener angles and plates fitted in place.

All the reaming of girder webs is done with the girders lying flat in all shops. Most shops rivet the web in the same position, though some stand the girder upright. The advantages of keeping the girders in their normal position is the economy in space and because it is much easier to keep them straight.

The above are only a few of the many interesting details connected with the fabrication of steel bridges in the shop, which, as I stated at the beginning of this article, I would have to touch on without a great deal of thoroughness, but I trust this fact will not make the article entirely valueless to the reader.

THE SELECTION OF ELECTRICAL EQUIPMENT FOR STEEL MILLS.

BY F. M. STURGESS, E. E.*

In the early days of the application of electrical equipment to the various processes of steel manufacture the street railway motor was adopted, as the requirements of street car service were thought to be as severe as that of the steel industry. But time and experience proved that the steel industry required a more rugged equipment because it was far more severe on account of the more frequent reversals, a higher initial temperature of the surrounding atmosphere, and the gases, grease and scale which are present. These conditions called for a stronger construction, a better grade of insulation and a gas and dust-proof frame. It was, therefore, found necessary to design a special line of apparatus for the steel industry, and as a result the manufacturer and the consumer got together in the fall of 1907 and decided to work the problem out. The present mill-type motors and controllers are the result of their combined efforts. These have proved so satisfactory from the start that both the manufacturer and consumer concluded that it would be to their advantage to work together in selecting the equipment for the various applications.

Today we find that all the large electrical manufacturers have a complete line of standard motors, controllers, etc., for steel mill applications. But as the Westinghouse Electric and Manufacturing Company were the pioneers in the movement which has proved to be so satisfactory to both the consumer and the manufacturer, a description of their apparatus will be taken for example.

Their mill motors are built with heavy cast-steel, dust-proof frames, large shafts and bearings, and fireproof insulated coils. Repairs and replacements are rarely needed, but all parts are arranged so that they can be quickly removed in case of accident. In the direct current type the commutator bars have a liberal wearing depth, and the commutator bushing is pressed onto the armature spider and keyed. The space between the commutator and the armature core is closed and dust-proof. Fig. 1 is a cut

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of the type MC direct current mill motor, and Fig. 2 is a diagram of the armature of this motor.

This type, being equipped with interpoles, gives the following advantages: (1) Practically perfect commutation under all conditions of load and voltage within the capacity of motor. (2) No injurious sparking when the motor starts with very high torque or is momentarily overloaded. (3) Greatly increased working capacity, owing to increased commutating ability. (4) Low repair expense and great continuity of operation, owing to long life of commutator, brushes and brushholders.

The main poles are laminated and the commutating poles are solid steel forgings. All poles have overhanging tips shaped to

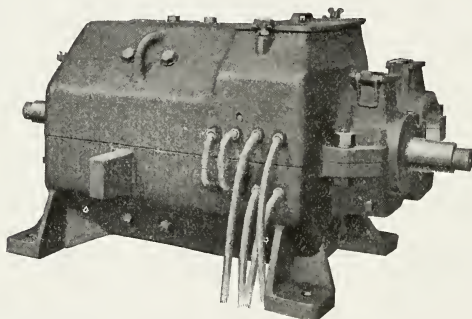


Fig. 1. Type MC Motor.

cause proper flux distribution and to hold the coils in place. The tip on the bottom commutating pole is removable, so that the coil can be removed without removing the pole. There are usually enough shunt turns on the compound-wound motors to prevent the no-load speed from exceeding twice the full-load speed. The series coils are insulated with asbestos and mica. Shields are placed between the coils and the pole tips and between the coils and the frame to hold them securely in place and to prevent injury to the coils from vibration.

The armature is of the laminated drum type with open slots. The lamination and the commutator are mounted on a malleable iron spider, which permits the removal of the shaft without disturbing the armature windings and commutator connections, and also reinforces the shaft. The armature coils are form wound of

asbestos covered wire or strap, insulated with mica and asbestos tape and dipped into insulating varnish. The coils are laid in slots lined with insulating material and separated by mica, and they are held in place by wedges and band wires. The projecting ends of the coils are banded down on the end bells of the spider to prevent flaring from centrifugal force. The diameter is comparatively small, so that the fly wheel effect is small; this permits of quick starting, stopping and reversing.

The brushes are of carbon with copper shunts, and are comparatively long and narrow in cross section, so that they follow the commutator closely. The brushholder is of the box-type and is carried by two steel rods which are clamped to the frame by a single bolt. See Fig. 3. The holder is insulated from the frame

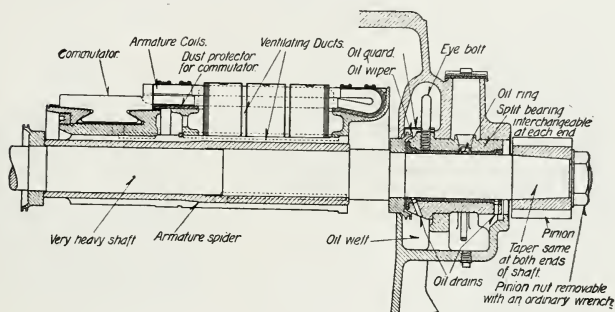


Fig. 2. Diagram of Armature of Type MC Motor.

by a porcelain bushing and micarta tube around each supporting rod. The micarta tube is protected from injury by a brass sleeve, which is pressed on.

The cast-iron, babbitt-lined bearings, Fig. 4, are supported in the bearing housing which is cast with the frame. The halves of the bearings are held in alignment by tongue-and-groove joints and held together by tap bolts. The two bearings of a motor are interchangeable, so as to reduce the number of spare parts required. Steel washers at the end of the bearings make them dust-proof. Eyebolts in the bearings make the removal of the armature easy.

Heavy cable terminals are brought out through the frame by insulating bushings and are equipped with connectors which are

very easy to disconnect. The terminals are brought out on the same side as the hinge, so that the motor can be inspected without being disconnected. In case of accident the whole machine is made accessible by removing the upper half of the frame which is hinged to the lower half.

Since the design of the alternating current motor is along similar lines, mechanically, to that of the direct current motor, it can be used on the same foundation and with the same pinions and gears if of the same capacity and speed. Only three sizes of

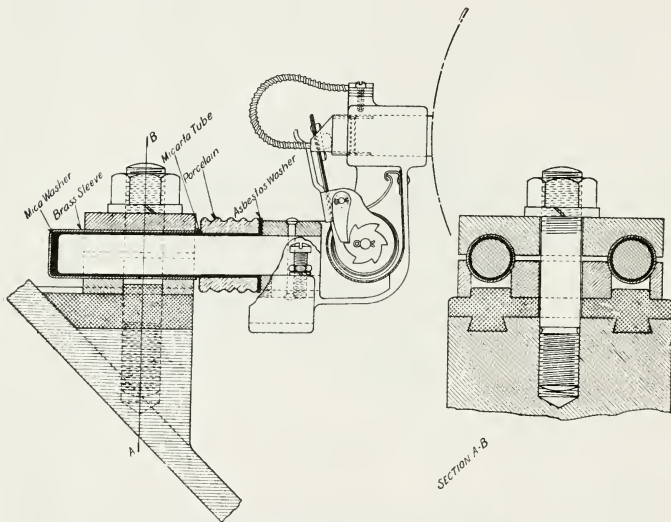


Fig. 3. Diagram of Brushholder of Type MC Motor.

brushes are used on the entire line of wound-rotor type motors. This helps to reduce the number of spare parts required. The heat dissipation is taken care of by ventilating plates on the end of the rotor and they carry the heated air to the frame. This design equalizes the heat and prevents hot spots. A diagram of the rotor and bearing housing of the type MA motor is shown in Fig. 5. The brushholder rigging of this line of motors is shown in Fig. 6.

These motors are suitable for roller tables, screw-downs, ladle cranes, mixer cranes, charging machines, ore handling machinery

and any other kind of service requiring a rugged design and a motor that can be easily and quickly repaired in case of accident. To select a proper motor for one of these applications a study of the cycle of work is made and the motor chosen as follows:

Required a motor to operate for five hours or continuously an ore bridge as follows:

	Horse- power	Seconds		
Closing bucket	50	8	50 ² x 8	20,000
Hoisting loaded bucket....	120	10	120 ² x10	144,000
Trolley in	0	10	0 x10	0
Opening bucket	20	8	20 ² x 8	3,200
Trolley out	0	10	0 x10	0
Lowering bucket and dy- namic breaking	50	9	50 ² x 9	22,500
Totals		55		189,700

Time of one complete cycle, 55 seconds; square root of mean square equals the square root of 189,700 divided by 55, or 58.7 horsepower. On five-hour horizontal line of Table I note 62 horsepower is the nearest standard rating and is built on the No. 90 Frame.

TABLE I.

Frame No. 80.				Frame No. 90.		
R. P. M.				R. P. M.		
Hours	Horse- power	Series	Com- pound	Horse- power	Series	Com- pound
5	44	680	600	62	650	527
4½	45	670	593	63.5	640	524
4	48	640	584	65.5	630	520
3½	50	620	575	68.5	618	516
3	53	600	567	71.5	605	511
2½	58	570	558	76.5	577	505
2	64	540	550	83	550	494
1½	70	515	537	91	515	485
1	80	480	520	100	500	475
½	100	430	475	150	400	425
¼	120	400	460	190	360	385

In case the motor is to perform its cycle of work for a period of two hours and then have a period of rest the problem can be solved in the same manner and the two-hour rating is taken from

the table. Tables for all the different sizes are furnished by the manufacturer.

The design and construction of all the electrical equipment required for the steel industry has been gone into with the same care and consideration for the conditions to be met as that of the motors. Automatic control of motors has replaced the manual controllers, so that the operation of the motors is not up to the operators. The resistance and the relays of the automatic controller can be adjusted to suit any particular application or requirements; and thus a motor is started as quickly and as perfectly as possible each time. Fig. 7 shows a cut of this type of controller and Fig. 8 is a detail of the resistance switch.

Ruggedness and simplicity of design are also carried out in the larger motors and controllers which are used to drive the roll

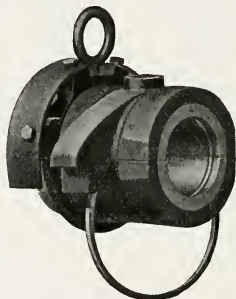


Fig. 4. Armature Bearing and Oil Ring.

trains in the various kinds of mills. These controllers have as few working parts as possible and the motors are accessible for repairs as it is possible to make them. It is a very simple matter to remove the coil from the rotor of a large roll train motor in case of accident. As shown in Fig. 9, the coils are held down by brass sectors bolted to the end bells of the spider instead of a continuous band wire. Delays in case of accident to one of the coils are reduced to a minimum.

In the selection of a roll-train motor, information regarding the following points should be studied:

1. Kind of mill, whether two-high reversing, two-high non-reversing, or three-high non-reversing.
2. Quality of steel or iron rolled.
3. Size of mill.

4. Revolutions per minute of rolls.
5. Number of stands of rolls.
6. Reversals per minute of stock rolled.
7. Time required to roll one piece of stock.
8. Speed cycle.
9. Torque cycle (at surface of rolls).
10. Horsepower cycle.
11. Is speed variation required? If so, how much?
12. Is motor to be reversed? If so, under what conditions?
13. Is motor to be direct connected or geared?

If sufficient data regarding speed, horsepower, and torque cannot be determined so that curves can be plotted, the principle points regarding maximum load and duration of same, also the approximate period of no load and full load during one cycle

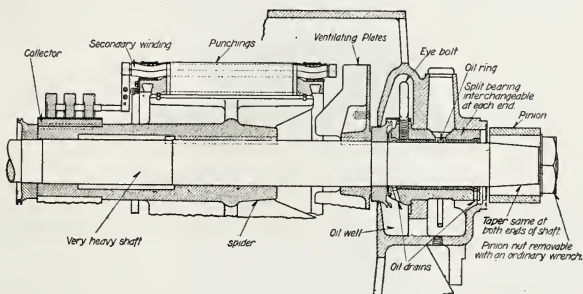


Fig. 5. Diagram of Rotor and Bearing Housing of Type MA Motor.

should be determined if possible. With the above data a motor to suit the exact conditions can be designed.

An equipment that has proved very satisfactory for two-high, reversing mills consists of a shunt-wound motor which is direct connected to the rolls and which gets its current from a motor-generator set driven by an induction motor with high resistance end rings. The resistance of these end rings is such as to give from 10 to 20 per cent slip at full load. The reversing of the mill motor is accomplished by field control of the generator.

For a two-high, non-reversing mill where the load lasts for a few seconds an alternating current motor with wound-type motor and external resistance, or a compound-wound direct current motor should be used with a flywheel. The full load slip of the induction motor should be about 15 per cent, so that the

flywheel can act efficiently. An induction motor with high resistance end rings would also be suitable. Where it is desirable to use standard speed motors they can be geared to the rolls, which usually have a speed of from 80 to 100 R. P. M.

In the case of a continuous billet mill where there are a number of sets of rolls (two-high non-reversing) the total load is practically constant, and a constant speed motor would be suitable to run the whole mill. No flywheel would be required. The different speeds of the rolls could be taken care of by different gear ratios from the main shaft.

A three-high, non-reversing mill rolling plates or structural shapes usually requires a varying speed motor. In alternating current installation a wound-rotor type motor with adjustable resistance giving 15 to 20 per cent slip at full load is used in connection with a flywheel. A compound-wound direct current



Fig. 6. Brushholder of Type MA Motor.

motor with flywheel and field control can be used. Mills rolling rails over 40 pounds from blooms would require the above equipments.

For three-high mills rerolling old rails or rolling light rails a two-speed motor is required. The following two-speed alternating current outfit has been tried out and found very satisfactory. This consists of a 1200-horsepower 25-cycle and a 600-horsepower $8\frac{1}{3}$ -cycle motor mounted on a common shaft with a common bedplate and operates as follows: Eighteen hundred horsepower at 80 R. P. M. is obtained with the primary of the 600-horsepower motor connected to the secondary of the 1200-horsepower motor. The secondary of the 600-horsepower motor is connected to the external resistance and the primary of the large motor is connected to the line. Twelve hundred horsepower is obtained at 120 R. P. M. from the large motor alone. By means of the secondary resistance the slip can be varied from 3 to 20 per cent. The flywheel weighs 36,000 pounds and is 22 feet in diameter.

The selection of the detail equipment requires the same care as that for the power apparatus, and it must conform to the

safety rules laid down by the steel industries. All switches and rheostates should be placed in fireproof boxes with locks accessible only to authorized persons. Large control panels should be protected by suitable railings and guards. The wiring of the entire equipment should be placed in conduit where it comes below the roof truss, so as to be protected against mechanical injury from cranes and other moving machines.

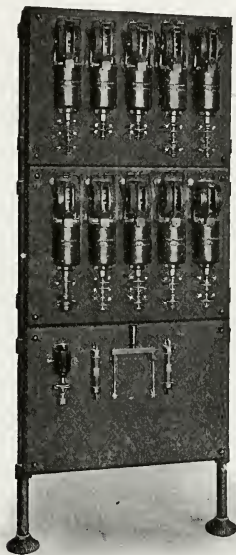
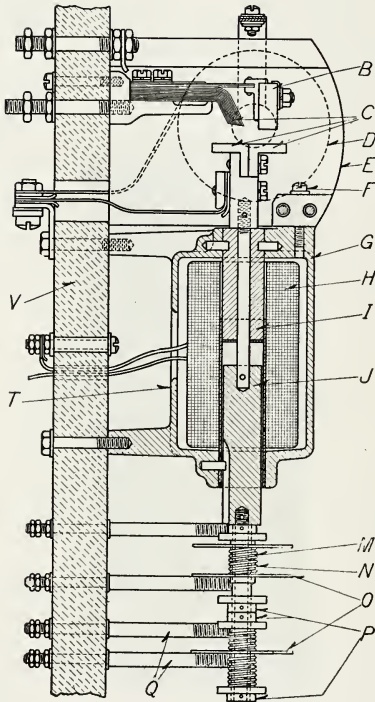


Fig. 7. Magnet Switch Controller.

Local conditions will determine the selection of a proper feeder system. However, this problem in a steel mill will be the same as for general applications. A voltage of 275 or above is considered high tension in a mill, and all small motors should have a lower voltage if possible. Where the voltage has to be over 275 the motors and auxiliary apparatus should have extra safeguards provided.

The construction of busses and line where large roll train motors are fed at a distance by high tension requires the most



B—Graphite Arcing Contact.
 C—Copper Contacts.
 D—Blow-out Coil.
 E—Arc Shield.
 F—Arc Shield Fastener.
 G—Magnet Cap.
 H—Magnet Coil.
 I—Stationary Core.

J—Plunger.
 M—Insulating Tube.
 N—Interlock Spring.
 O—Interlock Disks.
 P—Insulating Bushing.
 Q—Interlock Fingers.
 V—Panel.
 T—Magnet Frame.

Fig. 8. Diagram of Magnet Switch.

careful consideration. The insulators and their supports should be of ample capacity to take care of extremely large overloads and surges. Power service must be maintained continuously, and breakers therefore are not set to trip out on every little disturbance. Therefore, with large generating capacity, when a surge comes, due to starting or stopping a roll train motor, the enormous flow of current may pull the lines together and cause a destructive short circuit which in ordinary construction would tear out the buss structure. On 6,600-volt work, 11,000-volt

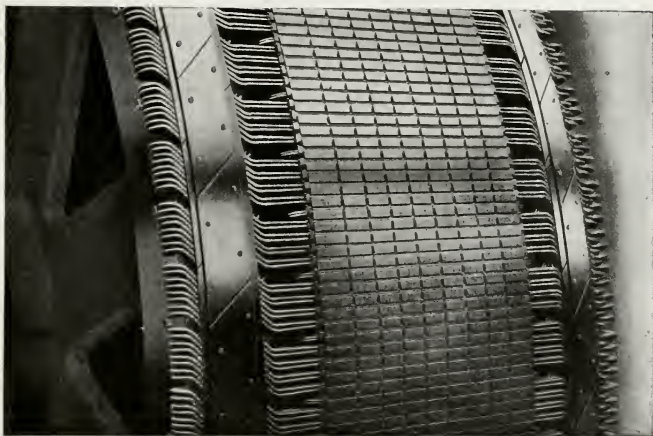


Fig. 9. Method of Holding Down Coil Ends of Roll Train Motor Secondaries.

insulators and supports are none too large. All compartments should be thoroughly isolated by good barriers. The disconnecting switches may have to be provided with latches to prevent them from flying open and starting a destructive arc.

The subject of illumination should not be neglected, as the shops in a mill are required to turn out first-class work. For this the tungsten lamp with the wire type filament has proved to be very satisfactory. Great care must be taken to get the proper distribution of light on the working plane. The arc lamp is used to some extent for general yard lighting, but in many cases the tungsten can be used for this purpose also. The ease

of maintenance and reliability, as well as the quality of the light given, are the reasons why the tungsten lamp has been used so extensively.

In selecting the electric equipment to be used in steel mills the most important feature to be considered is reliability; then follow efficiency and cost, respectively. As the process in the manufacture of steel is continuous, it is very necessary that the equipment perform its duty continuously, or else delays costing many times the value of the apparatus will result. Efficiency must, therefore, be sacrificed for reliability; and since the value of the product is many times that of the equipment, the cost should not necessarily determine the apparatus to be used.

SILOXIDE, AN UNRIVALLED SUBSTITUTE FOR QUARTZ GLASS.†

BY DR. ING. FELIX THOMAS.*

The properties of quartz glass are so well known today that it is quite unnecessary to give any detailed description of these. The widespread use of this product—as, for example, in chemical industries—shows what importance is attached to the typical properties of quartz glass, namely, its power to resist the action of acids and its resistance to widely divergent changes in temperature. These and other advantages are particularly apparent in vessels constructed from pure rock-crystal, which, however, is at the present time still far too expensive for industrial use and is employed only in the laboratory and for a few special purposes; I refer to the quartz glass mercury vapor lamp. The material commonly designated as “quartz glass”—(the term, “sand glass” has failed to establish itself)—is, as is well known, pure, amorphous, but non-transparent silicic acid, which has all the outward properties of glass, but in chemical composition is of course not glass at all. Moreover, this opaque quartz glass, which at the present time is on the market principally as an English product under the name of “vitreosil,” has essentially all the prominent properties of molten rock-crystal, though in a somewhat less degree. In particular it lacks the high mechanical stability of the latter and is more liable to devitrification, that is to say, it shows a far greater tendency to pass at high temperatures from the amorphous to the crystalline state, whereby the valuable mechanical properties are almost entire lost;¹ it is also extremely sensitive to the basic metallic oxides and alkaline earths, and of course especially so to alkalis proper.

*Translated and revised from the German by M. Woldenberg, Sc. B., Ph. M., Ph. D., class of 1906. Chemical Engineer, Woldenberg & Schaar, Chicago.

† Original German article in the “Chemiker Zeitung,” 1912, No. 4.

¹ Mention may here be made of the interesting work of A. Blake dealing with the loss of stability caused by devitrification and the change of structure connected with it. Compare also, “Die Glasindustrie,” 1911. Vol. 22, Nos. 43-45.

An endeavor had, therefore, to be made to discover a material in which the above-mentioned deleterious properties of quartz glass should be entirely, or at least partly, lacking. This was achieved in a certain degree by the smelting of glasses of a thoroughly acid character from mixtures of silicic acid with oxides of zirconium, and titanium. These oxides were chosen principally because their high melting-point appeared peculiarly adapted to give to these new acid glasses one of the chief advantages of quartz glass, namely, a high degree of infusibility.

At the request of Privy Councillor Professor W. Borchers, I undertook to experiment with the new acid glasses with a view to determining how their most important properties for technical and scientific purposes could be compared with those of quartz glass. Although these experiments are not yet concluded I feel satisfied in publishing here for the benefit of experts the surprising and significant conclusions which have so far resulted from my investigations. For these glasses², which are made from a mixture of pure quartz and acid oxides possessing a high melting-point, I have chosen the collective name of "siloxide," which implies a solution of oxides or their silicates in an excess of silicic acid. The experiments so far carried out extend on the one hand to zirconium oxide-silicic acid and on the other to titanium oxide-silicic acid, and in part also to the zirconium oxide-titanium oxide-silicic acid group.

The method of experimentation and other details I propose to publish in a comprehensive treatise at the conclusion of my tests with the other oxides. At this point I will only make known the results so far as they are of practical interest and most clearly illustrate the advantages which the new material possesses over quartz glass.

I. Zirconium Oxide-Silicic Acid (Z-Siloxide, Zircon Glass).

The objects experimented with consisted of tubes of different diameters (3—30 mm.) of a uniform length of 200 mm.; of cubes of different sizes; and rods having a cross section of 1 sq. cm. and a length of 140 mm. These were given to me by the patentee of these glasses, Dr. Franz Wolf-Burckhardt of the Electrothermal

² In a chemical sense these glasses are distinguished from glasses proper by the fact that they are formed from silicic acid and acid oxides, whereas glass as such consists of silicic acid and a predominating amount of basic oxides.

Works at Seebach-Zürich, through their sales agents, the Zirkonglas Company, of Frankfort-on-the-Main.

1. *External Properties, Color, Finish, etc.* The superficial appearance of the thin tubes of zircon glass is indeed not as alluring as that of the English vitreosil tubes with their silky surface, but this is the only point in which zircon glass falls short of vitreosil. In all other respects, so far as the experiments have yet been carried out, zircon glass has considerable advantages over vitreosil and also over the quartz glass of the Deutsche Quartz-Gesellschaft in Beuel (now in liquidation), whose products, so far as quality is concerned, were inferior to the English vitreosil. The zircon glass products have a dull finish and, if rich in zircon, a pale yellow color. They appear to be denser and firmer than the ordinary quartz glass products, as is clearly shown when zircon glass is cut on corundum wheels, the wear and tear of these being much more remarkable.

2. *Resistance (a) to Bending.* As a general truth, applying equally to all opaque quartz glass and to every kind of siloxide, I may state that the relative breaking strength (measured in kgs. per sq. cm.) of rods and tubes having diameters up to 8 mm. is considerably higher than in the case of those of greater diameters. Thus Wachenroder³, for example, puts the breaking strength of quartz tubes having an external diameter of 4 mm. at 860 kgs. per sq. cm., whereas those with a diameter of 7.5 mm. have a breaking strength of only 643 kgs. per sq. cm. I myself found in the case of tubes of the same material (vitreosil), with a diameter of 8.5 mm., a breaking strength of only 430 kgs. per sq. cm.

In the above-mentioned work by Blake the relative breaking strength of glazed quartz glass rods having a rectangular cross section (1—3 mm. by 5—10 mm.) is given as 382 kgs., that of the silk-finished material (presumably also vitreosil) as only 281 kgs. Blake's observation that the silk-finished material shows the lowest degree of infrangibility coincides with my own experience. *This material is, in a state of tension similar to that of badly annealed glass*; for instance, if a thin tube of vitreosil is laid somewhat roughly on a stone or iron plate, it usually snaps clean off at one point, just as if it had been cut. In some instances I observed that such a tube when so treated actually flew into several fragments and that the fractured surfaces were quite smooth and even. In most cases a few particles were hurled to some considerable distance.

³ Chem. Nachr. 1910, No. 10.

On subjecting such tubes to a strain on the bending machine I made the following observation: if the specimens tested remained for several seconds under a strain less than that of their breaking-point, the fracture took place suddenly, without any alteration in the load, so that the ends of the tubes were hurled some decimeters away. I have therefore come to the same conclusion as Blake, *that the brittleness of the silk-finished material is due to the fact that it is in a state of constant tension.*

In order to arrive at figures for purposes of comparison I selected for experiment tubes of some 30 mm. external diameter, having first satisfied myself by some preliminary trials that a variation one way or another of a few millimeters in the diameter causes no essential loss or gain in the relative breaking strengths; only in the case of very thin-walled tubes was the breaking strength especially unsatisfactory. (For which reason the values thus obtained were eliminated by computing the mean breaking strength.) The results of the tests for bending strength are given in Table I below.

In this table V denotes vitreosil, a pure quartz glass manufactured by the Thermal Syndicate, Ltd., Wallsend, England; "Q" represents the pure quartz glass of Dr. Franz Wolf-Burckhardt, of the Electrothermal Works at Seebach-Zürich, Switzerland; ZS stands for zircon glass, a product of the last-mentioned firm. The figures after ZS denote the percentage of ZrO_2 in the composition.

TABLE I.

De- scrip- tion.	Breaking strength in Kgs./sq.cm.	Thickness of tube in mm.	Remarks.
V	(a) 110 (b) 86	(a) 3.0 (b) 2.8	
Q	(a) 150 (b) 350 (c) 148	(a) 2.1 (b) 2.9 (c) 2.0	
ZS 0.1	(a) 350 (b) 274	(a) 3.3 (b) 3.2	Probably an excep- tional value in ob- servation (c). Thin places in the tube. (b) Broken at the end.
ZS 0.5	(a) 219 (b) 175	(a) 3.4 (b) 3.3	
ZS 1.0	(a) 326 (b) 416 (c) 380	(a) 3.1 (b) 3.4 (c) 3.4	
ZS 2.0	(a) 227 (b) 162	(a) 3.0 (b) 3.1	
ZS 2.5	(a) 255 (b) 183	(a) 2.1 (b) 1.9	

It appears that a tube of smaller thickness shows a smaller relative breaking strength than a similar tube of greater thickness, so that tubes of about 30 mm. diameter ought to have a thickness of not very little less than 3 mm. if they are to withstand the strain of bending given above.

b) *Pressure Resistance.* The experiments carried out with the same materials (vitreosil excepted) with a view to pressure resistance had the results given in Table II. As test specimens, unless otherwise noted, cubes having an edge of 20 mm. with unglazed surface were employed.

TABLE II.

De- scrip- tion. Q	Pressure Resistance.			Actual Breakage.			Remarks.
	Appearance of first flaw.						
	(a) 190 (?)	(b) 470		(a) 1200 (?)	(b) 921		In the case of [observation (a)]uncertain.
ZS 0.1	(a) 610	(b) —	(c) 387	(a) 1103	(b) 914	(c) 905	
ZS 0.5	(a) 502	(b) 468		(a) 923	(b) 763		
ZS 1.0	(a) 665	(b) 452	(c) 451	(a) 1830	(b) 1008	(c) 966	
ZS 2.0	(a) 198	(b) 278	(c) 246	(a) 676	(b) 694	(c) 835	
ZS 2.5	(a) 320	(b) 343		(a) 793	(b) 993		

If the average values of these tables are represented in a system of co-ordinates we obtain the curves shown in Diagram I for the pressure and bending strengths, which agree in showing that by the addition of 1 per cent of ZrO_2 to pure quartz glass the ability to resist pressure and bending is appreciably increased. Even 0.1 per cent has a quite perceptible effect in the right direction, whilst in both cases with 2 per cent we can affirm a minimum of strength which—so far at least as strain of flexure is concerned—far surpasses in value that of pure quartz glass.

3. *Devitrification.* The extent of devitrification was determined by heating the tubes undergoing the test in an electrically heated tubular carbon furnace for one or two hours at the temperature best adapted to accelerate the devitrification and in the atmosphere most unfavorable to the material (CO). The objects were then removed from the furnace, and after cooling off in the air (in some cases after being chilled in cold water) the devitrified flakes were immediately measured. At the place of fracture it is readily seen how far the process of crystallization has advanced, for at these points the material has completely lost its "glassy" characteristics. Blake's method of determining the intensity of the devitrification by measuring the loss of breaking strength was unfortunately impossible by me, since the large number of tubes necessary for this purpose were not at my disposal.

The degree of devitrification can, however, be ascertained, qualitatively at least, without measuring the thickness of the devitrified flakes, by means of the "ring" given out by the objects of experiment. Perfectly amorphous tubes have a clear resonant "ring" like that of hard porcelain; as the devitrification increases the sharpness of the tone is lessened, and with complete devitrification the tube rings as if it were quite cracked, which is actually the case since the tube now consists only of adherent Tridymite-crystals. Moreover, with complete devitrification the tube can be crushed between the fingers, a clear proof of the thorough change of structure that has taken place. Of this less quantitative method of determining the degree of devitrification I have availed myself in the course of my experiments. The results are summarized in the following Table III.

TABLE III (INVARIABLY CO-ATMOSPHERE).

Description. V	Temp. in °C.	Hours Duration	Degree of Devitrification.	"Ring" (Sound)
	1500	1	Flake $\frac{1}{2}$ mm. thick; centers of crystallization within.	Inferior.
Q	1500	1	Flake $\frac{1}{2}$ mm. thick; centers of crystallization within.	Tube partly melted.
ZS 0.1	1350	1	No trace of devitrification.	Fully preserved.
do.	1450	5	Fully devitrified; able to be crushed between the fingers.	None.
ZS 0.5	1430	1	Tinged with white deposit which was easily wiped away.	Fully preserved.
The same tube (1)	1500	1	Flake abt. $\frac{1}{4}$ mm. thick; tube not attacked by the oxide.	Good ring; therefore no crystallization within.
ZS 0.5	1500	1	Flake abt. $\frac{1}{4}$ mm. thick.	Good ring.
The same tube	1650	1	More than half devitrified.	Strongly affected.
Q	1600	1	Strongly devitrified, also within.	Strongly affected.
ZS 1.0	1500	1	Tinge, but within isolated centers of crystallization.	Tube very brittle.
ZS 1.0	1700	$\frac{1}{2}$	Tube somewhat deformed, but still quite serviceable; no devitrification, of course, owing to the fact that the softening point had been passed.	Still fairly good.
ZS 1.0	1680	$\frac{1}{2}$	No devitrification; tube somewhat glazed.	Ring better than before the heating.
ZS 2.0	1500	1	Somewhat more strongly devitrified than ZS 1.0 at 1500° C.	Improved.
do.	1680	$\frac{1}{2}$	Somewhat glazed, but no devitrification.	Fairly good.
ZS 2.5	1500	$\frac{1}{4}$	$\frac{2}{3}$ cross section devitrified.	Good.
do.	1500	1	More than $\frac{3}{4}$ cross section devitrified.	Strongly affected.
				No ring.

(1) Tube filled with metal filings rich in oxides.

Thermally the best material is therefore that containing 0.5 per cent of ZrO_2 , and in the second place comes that with 1 per cent. The latter material is, however, mechanically the most resistant, so that I recommend the choice of ZS 1.0 to satisfy mechanical claims, but ZS 0.5 for thermal purposes, while for both objects an intermediate mixture of about 0.75 per cent should be chosen.

4. *Resistance to Alkalies and Basic Metal Oxides.* Experiments to determine the resistance of zircon glass to alkalies (solutions of soda and potash, caustic potash and caustic sodium lyes) are not yet quite finished, but apparently in this respect also zircon glass is superior to pure quartz glass. That it is also more able than quartz glass to withstand the basic metal oxides, is shown by the following observation made by an eminent chemist, a gentleman who has worked a great deal both with quartz glass and zircon glass. A zircon glass tube placed in a magnesia tube or in a crucible coated with magnesia and in direct contact with the magnesia was not affected until it had been heated for half an hour in a temperature of 1500°C., and even then it was in every way fit for further use, whereas a quartz glass tube of the Deutsche Quartz Gesellschaft at Beuel, was almost instantly turned into slag.

5. *Softening Points. Miscellaneous.* The softening points were determined by heating thin tubes of about 4 or 5 mm. in diameter and 40 mm. in length, the tubes being supported only at the ends, so that as soon as they began to soften they had to bend, a point which could be ascertained fairly accurately. The temperatures were measured with the Wanner pyrometer. The softening point of the pure quartz glass handed to me by the Zirkonglas Company of Frankfort-on-the-Main was found to be 1734° C. with quick heating; that of the zircon glass averaged 1750° C. When slowly heated the quartz glass tubes began to lose their shape at about 1770° C. The difference in the softening points of the quartz glass manufactured by the Zirkonglas Company and its zircon glass is therefore inconsiderable. A fact of great importance for many practical purposes is, that zircon glass loses its shape far more slowly than quartz glass, and that on account of its extreme viscosity.

Larger tubes can be heated for several minutes to the temperature at which softening begins to set in, without any risk of collapsing; they may perhaps somewhat lose their shape, but they will not in any way be unfit for use. Nevertheless zircon glass is very easy to work with the oxy-hydrogen blowpipe; above all it gives no signs of the very troublesome bubbles met with in the case of the Beuel material, so that, for example, two zircon glass tubes can very easily be welded together without any formation whatever of blisters. Finally, still another property of zircon glass is its adaptability to cutting in the shape of tubes.

In cutting larger tubes on carborundum wheels, one has to set carefully to work because quartz glass very easily flies apart. I frequently observed in the case of the larger tubes of Beuel quartz glass, fractures along their entire length. Zircon glass can be treated somewhat more roughly without having to fear a fracture; the breaking out of larger pieces, even when the object worked is pressed with considerable force against the carborundum wheel, is comparatively rare. The small tubes can be cut, though perhaps a trifle less conveniently than quartz glass, with a triangular file.

II. Titanium Oxide-Silicic Acid (T Siloxide, Titan Glass).

The objects experimented upon were the same as in the case of zircon glass (tubes, cubes, rods, etc.) and of similar dimensions. This product also was handed to me by the manufacturer, Dr. Franz Wolf-Burckhardt, of the Elektrothermal Works, Seebach-Zürich, per the Zirkonglas Company, Frankfort-on-the-Main.

1. *Surface Properties, Color, Finish.* Since in the melting of titanio acid with silicic acid in a reducing atmosphere the former is reduced to a lower stage of oxidation, the resulting product has a bluish color, varying from light to dark according to the quantity of titanium added. In the case of a smaller percentage of titanium the glass, if in thin flakes, compares quite favorably with quartz glass in point of transparency; in the case of a greater percentage of titanium the glass is of course far less transparent, a circumstance which, however, is of no consequence for most purposes.

2. *Resistance (a) to Bending.* What has already been said in the case of zircon glass applies here also. The values obtained are summarized in the following Table IV.

TABLE IV.

Description.	Breaking strength in Kgs./sq. cm.	Wall-thickness of tubes in mm.	Remarks.
V	(a) 110 (b) 86	(a) 3.0 (b) 2.8	
Q	(a) 150 (b) 350 (?) (c) 148	(a) 2.1 (b) 2.9 (c) 2.0	
TS 0.1	(a) 471 (b) 471	(a) 3.5 (b) 3.4	
TS 0.5	(a) 386 (b) 376	(a) 3.1 (b) 3.0	
TS 1.0	(a) 152 (b) 199	(a) 2.7 (b) 3.5	Material porous.
TS 2.0	(a) 481 (b) 427	(a) 4.3 (b) 3.9	Material porous.
TS 2.5	(a) 278 (b) 302	(a) 3.6 (b) 3.8	

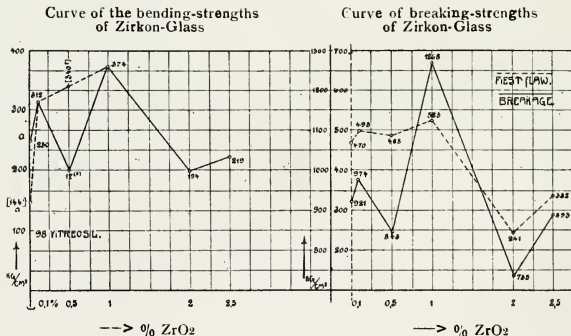


Diagram I.

Since the walls of the tubes vary considerably the curve of the breaking strength as a function of the thickness may be given for the purpose of clearer explanation. Taking the loads "P" as abscissae and the thicknesses, "S" as ordinates we obtain theoretically a curve like *a* in Diagram II. The most favorable

material will be that whose P-S curve at first runs evenly and then quickly ascends; moreover, the maximum resistance should of course lie as high as possible; that means starting with the smallest thicknesses the material must attain very nearly its maximum of relative resistance. In the case of metals these conditions will be almost fulfilled; in a certain degree they are met with glass, transparent quartz glass and similar bodies. Not, however, with opaque quartz glass and just as little with opaque siloxide, since in the two latter instances we have to deal with materials which are far from homogeneous. Here we have together with increased thickness a more or less increasing relative breaking strength.

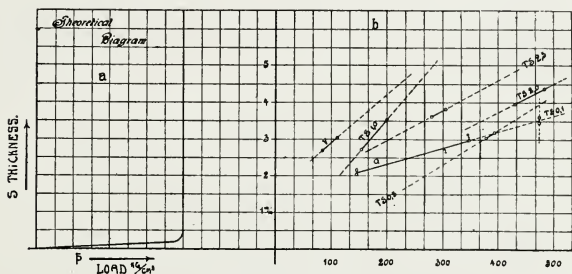


Diagram II.

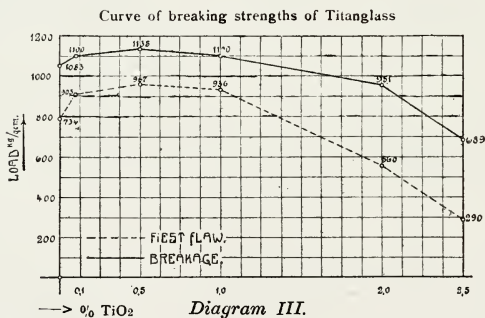
But here also the best material will be that whose P-S curve fulfills the above-mentioned conditions and as quickly as possible attains its highest maximum value. If we draw, so far as the few figures of the table permit it, the different curves, we obtain the curve b (Diagram II). TS 0.5 has apparently the steepest course and the greatest maximum; even steeper is perhaps TS 0.1 with the highest maximum value, though this cannot be positively asserted owing to the slight difference in the thicknesses of the two experimental tubes. TS 2.0 also has a good course and a high maximum, so that all the glasses from 0.1 to 2.0 per cent would appear to be suitable for use.

b. The experiments for pressure resistance carried out with the same material (vitreosil excepted) gave the results presented in Table V.

TABLE V.

TABLE V.						
De- scrip- tion. Q	Resistance in Kgs./sq. cm.			Actual breaking.	Remarks.	
	Appearance of first fracture.					
	(a) 189 (b) 470 (c) — (d) 1140			(a) 667 (b) 921	(a) Load irregularly applied.	
	Cube of 1 sq. cm. pressure surface					
TS 0.1	(a) 352 (?) (b) 856 (c) 955			(a) 1020 (b) 1190	(c) Load irregularly applied.	
TS 0.5	(a) 961 (b) —			(a) 1140 (b) 1130		
TS 1.0	(a) (111) (b) (114)			(a) — (b) —	Material porous. Load irregularly applied.	
TS 1.0	(a) — (b) 843			(a) 1030 (b) 1170		
TS 2.0	(a) 793 (b) 326 (?)			(a) 932 (b) 970		
TS 2.5	(a) 272 (b) 308			(a) 600 (b) 778		

The material Q is apparently the strongest but at the same time the most inelastic, being quite unable to stand loads jerkingly applied, whereas the TS material, since it appears to be in general somewhat more elastic, endures this unfavorable kind of test quite well; its relative resistance to pressure is, it is true, somewhat behind that of the Q material but comes very close to it in the case of the 0.1 per cent, and especially 0.5 per cent. In Diagram III the values of the above tables are reported graphically for better inspection.



3. *Devitrification.* As in the case of ZS material, this was definitely determined. The following table (Table VI) shows the observed results.

The TS material has therefore even a greater power of resistance against high temperatures than zircon glass, and that for all the percentages so far experimented with. The troublesome tendency to crystallization on the part of pure quartz glass when subjected to continued heat at a high temperature is here greatly reduced, so that in titanium glass we see a product both mechanically and thermally superior to quartz glass.

TABLE VI.

(Here also the work was invariably carried out in CO atmosphere.)

De- scrip- tion. V	Temp. in °C.	Hours Duration	Degree of Devitrification.	Ring.	Remarks.
	1500	1	Flake $\frac{1}{2}$ mm. thick; crystal- lization within	Inferior	Melted at the edges
Q	1500	1	Moderately devitrified	Inferior	
Q	1500	2	Completely devitrified	None	Could be crushed between the fingers
TS 0.1	1500	2	Flake quite thin	Good	Still very firm
TS 0.1	1500	1	Tinge of devitrification	Well preserved	
TS 0.5	1500	1	Tinge of devitrification	Well preserved	
TS 0.5	1500	1 $\frac{1}{2}$	Tinge of devitrification	Well preserved	
ZS 1.0	1500	1	Very thin flake	Preserved	
ZS 1.0	1500	2	Not perceptibly more devitri- fied than after 1 hour	Preserved	
TS 2.0	1500	1	Very slightly devitrified	Good	Appearance that
TS 2.0	1400	2	Tinge of devitrification	Fully preserved	of unused tube
TS 2.5	1500	1	Tinge of devitrification	Good	

The experiments concerning softening points, chemical resistance of titanium glass to alkalis (against acids, zircon and titanium siloxides are at least as proof as quartz glass) and some other problems are not yet concluded and will be published in a later treatise; also the properties of glasses obtained by the addition of other metallic oxides, whose examination is now in hand.

The properties of the zircon oxide-titanium oxide-silicic acid group have no special interest; in general they combine in each other the properties of the individual glasses, but have been tested only up to an addition of 1 per cent of the oxide mixture.

NOTE—The above experiments were carried out with the co-operation of Privy Councillor Professor Dr. W. Borchers in the course of 1911 in the Metallurgical and Electrometallurgical Institute of the Technical College at Aachen, Germany.

TWO ARMOUR MEN IN EUROPE.

[EDITOR'S NOTE—The authors of the two following sketches are members of the class of 1913, Course in Architecture, Armour Institute of Technology. Mr. Faulkner was the recipient of the \$250 Home Traveling Scholarship last year, and he and Mr. Bischof visited Europe during their summer vacation.

IMPRESSIONS OF FOUR GREAT CATHEDRALS.

BY C. D. FAULKNER.

Westminster Abbey—London.

Westminster Abbey, founded in the eleventh century by Edward the Confessor, destroyed three hundred years after his death, rebuilt by Henry III, and supported by all the royalty of the land, is surely the most interesting church in England.

On observing the Minster from Whitehall (N. E.), one cannot but be impressed by the vastness of the building. The many piers and buttresses flanking the nave, the triple doorway of the north transept, the flying buttresses of the apse, the beautiful Chapel of Henry VII at the rear, all—in fact, not a stone has been overlooked by that clever colorist, that great harmonizer which neither waits nor hurries for any man. The softening hand of Time has removed the sharp touches of the chisel from the rich tracery of the arches, the roses which once ornamented the key-stones have lost their leafy beauty, the quaint heads of men so familiar to Gothic detail have lost their features until now they are nothing but rounded knobs; and still there is something pleasing and fascinating in its very decay.

In plan the church is of the usual cruciform shape. Entering from the west, the front, one stands, so to speak, at the foot of the cross, the nave forming the beam, the transepts the arms, and the apse, with its semi-circle of small chapels the head. Behind the apse is the Chapel of Henry VII. Although the exterior may not be the best example of English cathedral exteriors, the

interior, with its graceful arcading of the triforium, the clerestory windows, then the roof one hundred feet above the pavement, supported by ribbed columns, all give that great charm of an avenue of trees with their interlacing branches vaulted so far above. Looking up at the roof, then at the people wandering about the nave, one is astonished at their insignificance when compared with their own handiwork.

Can you imagine yourself in a room a hundred feet high and about forty feet wide, but dimly lighted, the musty gray walls dating from the thirteenth century, all as still as death, before you



Westminster Abbey From Whitehall.

the grave of Edward the Confessor, over there the tomb of Richard II., and here the resting place of James I., in all, thirteen of the kings of England, five queens in their own right, besides many of the queens of the kings. Now passing from the apse, the burial place of royalty—and in passing, what little you have to say you unconsciously say in whispers—to Poet's corner. There in that old Gothic sarcophagus lies Chaucer, here Dryden, there Tennyson, there is Browning's grave, next to it is Spencer's, and here is Dickens', and over there rests Handel.

Would not the most gay become serious, would he not think a minute and ask himself, "After all, are these men dead, or are

they living and influencing us as we become broad enough to be interested in and intelligent enough to understand their thoughts as we read them?" Because Westminster is the mausoleum of many of the bravest and greatest men in history, it will not be forgotten until memories of the men interred there have been wiped out. Hence I feel that the building can be placed high among the world's great buildings whether its beauty lies in its architecture or not.

What little some may think is lacking in Westminster is more than made up in that gem of perpendicular Gothic, the Chapel of Henry VII. The chapel is entered from the apse of the main building by mounting several steps and passing through two wonderful brass gates. One's breath is fairly taken away on beholding the pomp of architecture, with its marvelous beauty of detail. The walls themselves seem to be hued into universal ornament, encrusted with tracery, and scooped into niches, crowded with the statues of saints and martyrs. The stone seems, by the clever manipulation of the chisel, to have lost its weight, and the wonderful fan-vaulted roof suspended aloft with the minuteness and airy security of a cobweb.

Along the sides of the chapel are the lofty booths of the Knights of the Bath, richly carved of oak. On the pinnacles of the booths are the helmets and crests of the Knights, with their scarfs and swords, and above them are suspended their banners of purple and gold, which form a pleasant contrast to the sober grey stone of the walls and roof. In the center of the chapel is the beautiful tomb of its founder and his queen. On walking round the small aisles on either side of the Knights' stalls one experiences a sad dreariness in looking at the graves, among which are those of Elizabeth and her sister, her victim, the unfortunate Mary.

Notre Dame—Paris.

This majestic pile has suffered much, due to Time and man, who seem to have united to mutilate: respect for Charlemagne, who laid its first stone (ninth century), or Philippe Auguste, who laid its last, made neither hesitate.

The great west facade, the finest part of the cathedral, with its three deeply dug porches and their pointed arches richly adorned with Gothic sculpture, that of the central door representing the Last Judgment; the frieze with its twenty-eight statues of the kings of France, all destroyed during the Revolution and restored afterward; the beautiful rose window in the center of the next division flanked with double pointed windows above which is the

high and lace-like gallery of open-work arches, supporting on its delicate columns a platform, from which level spring the two massive towers. The south one contains the great "Bourdon de Notre Dame"; a bell weighing sixteen tons, its clapper weighs



West Facade of Notre Dame.

nearly half a ton. The horizontal divisions of the front look to be the strong bands of confidence, the ties which bind together the family; the father and mother, the towers, which seem to shelter from the elements that small and beautiful central member.

But Time has not been as severe with the interior as with the exterior. Man alone, in the name of Revolution, has robbed it of its sculpture and carvings, its tracery. And so at the end of that madness, that great civil sickness, its life was in danger—let me say, its flesh had dwindled away, its bones were weak. But on the return of peace flesh came back, but not *its* flesh, but sculpture and ornament of the Renaissance, but *its* life, *its* spirit,—Gothic was not restored. Can there be anything more ridiculous than furniture and ornaments in Renaissance in a transitional Gothic building? Nevertheless there is so much charm, such fascination about the place that one wants to linger there. The



The Vastness of St. Peter's Is Overwhelming.

great nave; its warm colored, red and grey stonework; the soft, somber light as it comes through the beautiful stained glass rose window in the south transept or in the west wall has an hospitable, restful, soothing atmosphere which the tired stranger well appreciates. Notre Dame is indeed a restful place.

St. Peter's—Rome.

The mighty cathedral, the pivot of Roman Catholicism, is indeed a "very mountain of art." The size, the vastness of this overwhelming Renaissance building is amazing.

Looking at the front, what do you see? A three-story building with a dome? Perhaps. But compare the facade with a man on

the steps. Notice the scale! The facade is 369 feet wide and is ornamented with Corinthian columns 165 feet high (more than three-fourths the height of the Monroe Building). The statues on the cornice, above what appears to be the third story, are nineteen feet high.

The beautiful dome, the best view of which is from the rear of the church, seems almost to be the crown of jewels set far back on the bushy-haired head of a broad-faced king. The original plan of the church was the Greek cross (all arms equal), but three bays have been added to the nave, thus setting the facade so far



Cologne Cathedral Appears to Grow Out of the Ground.

forward that the dome is lost behind it when viewed from the street level. The dome is 138 feet in diameter and it is 435 feet from the pavement to the cross (twice as high as the La Salle Hotel). The ball at the tip of the dome is reached by a ladder and will hold sixteen persons at one time.

Can you picture a room of marble, mosaic, and gilded stucco; a room 150 feet high, and 615 feet long (nearly an eighth of a mile), near one end of which rises a dome of mosaic, and gold and white plaster, 404 feet from floor to ceiling? Remember this is *one room*, not a building: it is the "auditorium" of the church.

Services can be held in one of the chapels along the side of the nave, and at the other end of the church or in one of the transepts not a sound of this service can be heard. The area of the one floor is eighteen thousand (18,000) square yards.

Under the dome is the High Altar, which is covered by a canopy held by four twisted, gilded columns of metal 95 feet high. This stands over the tomb of the Apostle Peter.

Raphael, Bernini, Angelo, and many other famous men had something to do with the planning and building of this great church.

St. Peter's does not impress one as do the other cathedrals, especially the French, which are Gothic. It does not carry one back to the medieval days. You can not imagine the gorgeous costumes of the fourteenth or fifteenth century worn by people wandering about the nave. It is modern! It has never been surpassed in size or in beauty and will not be for some time to come. True, it was built a long time ago, but it has been favored by Time; it shows no scars, no signs of decay; it is as firm as the spirit in which it was built. It seems to be an indestructible expression of its function.

When one first enters the nave he is amazed at its size, overwhelmed by its beauty; he can say nothing, do nothing but stand in open-mouthed wonder. It is colossal.

Cologne Cathedral.

This great pile is justly called the "finest Gothic edifice in the world." It is a building which appears to have grown out of the ground on which it stands; every spire, every pinnacle seems to aspire to loftier relations.

Its two great towers are 515 feet high, just as high as the church is long. There are four stories to the towers, the lower three being square in plan, the fourth being octagonal, crowned with the beautiful open-work stone spires. In the south tower is the big bell, weighing twenty-seven tons, which requires twenty-four men pulling on the rope to set in motion.

Around the exterior is a two-fold series of massive flying buttresses ornamented with a multiplicity of little pinnacles. The doorways on the front and sides are beautified with some of the most exquisite carving; every detail is carried out.

The interior, especially the nave, is most impressive with its fifty-six pillars, its 390 feet of length, 48 of width, and 145 of height. Besides, on each side of the nave are two aisles, one 27, one 21 feet in width. The beautiful stained glass windows, some old, others modern, are wonderful.

One can but feel the greatest respect for this enormous structure. Its every detail complete, every ornament finished, its construction carried out with the greatest care and accuracy, all go to make it the last word in Gothic. A poet even goes so far as to call it "the eternal cathedral."

It seems a shame that one with ability enough to design such a building can not be given due credit. In 1257 the chapter gave a grant to Meister Gerard, whom it is thought was the designer. However, this is not definitely known. The reason for the uncertainty is "fully" explained in the following legend: The Pope ordered an architect to design a great cathedral to be built in Cologne. The drawings were completed and one day while the architect was taking them to explain them to the chapter he met Satan on the road. Satan said that he, too, had designed a cathedral for Cologne and unless his design was adopted and the architect's laid aside, the architect's name would never be known. The architect was a brave and prudent man; he refused; therefore his name has never been known.

WHERE KINGS HAVE LIVED.

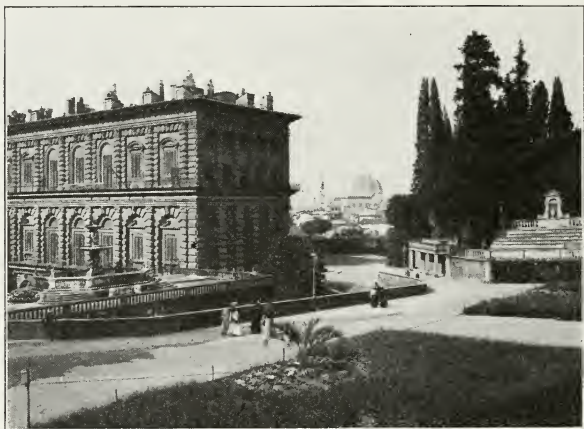
BY J. H. BISCHOF.

Probably nothing sounds quite so thrilling nor so stirs the imagination as does the thought of a king's palace. From fairy-tale days I have always had notions of just how such a magical place should look—stately halls of marble hung with elegant tapestries and crowded with splendidly garbed nobility—but last summer I had the opportunity to compare these conceptions with the palaces of both yesterday and today as they stand in reality. Of all the palaces which we saw none, of course, came up to the ideal which I so long had cherished. Many of the more modern ones looked like large houses that were once beautiful, but had been sadly neglected; however, there was not one but had an air of dignity and importance about it.

Buckingham Palace is the residence of King George and it comes under the heading of those palaces which, although comparatively modern, have an antiquated appearance. Designed in the stiff and uninteresting English Renaissance style, and built of stone that has assumed the color of rusty iron, it seems unfitting for the dwelling place of one of the great sovereigns. Directly in front of the palace and at the end of St. James' Park is the Victoria memorial monument, which is built of gleaming white marble and serves to make the royal home seem only more

dingy. The palace is now being provided with a new facade of white stone, which will be more in character with the dignity of the building.

The principal royal residence in England is at Windsor Castle, twenty-two miles from London, and beautifully situated on a high cliff overlooking the Thames. The castle is an immense structure and has a romantic and picturesque appearance, due to its location high above the river and its admirable grouping of turrets, towers and pinnacles. In August many of the buildings were almost covered with masses of ivy and Virginia creeper—scarlet,



The First Court, Showing the Round Tower, at Windsor.

purple and green—which enlivened the brownish-gray dullness of the stone and at the same time served as an attractive setting for the picture. The different buildings are all surrounded by a thick wall, and the general impression is that of a fortress. The Round Tower is massive and finely proportioned, and it majestically crowns the summit of a hill covered with brightly colored foliage. It is surrounded by a moat that dates back to the time of Henry II. Ascending the tower a fine view of the surrounding country was obtained—across the river lay Eton, with its famous college; farther still was the imposing Blenheim Palace, the home of the Duke of Marlborough; and beyond this rose the white spire of the church in the yard of which Gray

wrote his "Elegy." It is at Windsor that every foreign sovereign visiting England is entertained. The rooms of state are most attractive, combining delightfully the atmosphere of home life with the splendor of monumental halls and galleries. Here are finely carved woodwork, beautiful ceilings, rich hangings, furniture that seems fit only for people clad in velvets and ermine, and a dimly lighted banqueting hall two hundred feet in length, paneled with oak and lined with armor and trophies of centuries past.

Despite its many charms, Windsor is slightly inferior to Hampton Court—as architecture if not as a picture. Hampton Court is also situated several miles outside of London, and on the Thames; this palace was built by Cardinal Wolsey and here he lived in state, amid surroundings unequalled in all England for beauty, until Henry VIII. decided it was just the place to install his latest bride, and at his request the Cardinal moved out. The latter had a genuine regard for beauty, and the buildings that he built here still rank as among the finest examples of brick work, and today serve many architects as inspiration for fine country houses or city mansions. Henry recognized the Cardinal's ideas of building as superior to his own, so fortunately, he left the Hampton almost intact, except for minor changes—such as substituting his royal crest for that of Wolsey, erecting a gateway in honor of Anne Boleyn, and building a fine astronomical clock, which tells the month, the day, the hour and the quarter of the moon. The grounds and gardens at Hampton Court are at their best in June—winding walks lined with shrubs, formal gardens planted with the most beautiful of brilliant flowers, and blue lagoons from the depths of which come the flash of goldfish, or on whose mirrored surfaces float swans among the water lilies. At the end of the wide terrace lined with fragrant, blossoming orange trees lies the Thames with its luxurious, vine-covered houseboats, while at the other end stands the park, where several hundred deer graze under the chestnut trees.

The most famous of the palaces of France—the Louvre—is no longer a residence, but has been converted into the largest art museum of Europe. This palace, which covers over forty-five acres of ground, is on the Seine River, at the end of the Tuileries Gardens, and it has been added to by so many rulers and patrons of art—Francis I., Henri II., Catherine de Medicis, Louis XIV., and Napoleon—that it contains many styles of architecture. These additions have come to harmonize wonderfully well, due to the weather and age. The most interesting part of the huge palace is the Francis I. wing, while the latest addition, designed

in 1688 by Perrault, is an imposing 600-foot colonnade, which, however, has little connection with the rest of the building. But the Louvre is as remarkable for its beautiful sculptures by Jean Goujon as for its dignified architecture. The galleries within are a succession of monumental halls with wonderful ceilings and rich wood carvings. Of these halls the Galerie d'Apollon is the most sumptuously decorated, being one of the best examples of the Louis XIV. style.

About an hour's ride from Paris brings one to Versailles, with its famous park and palaces. The park, including the build-



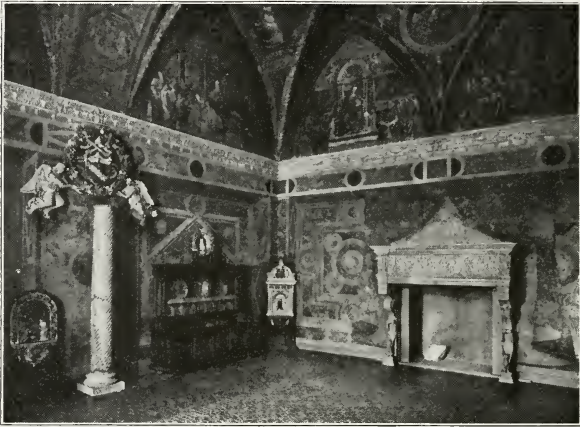
The Palace at Versailles. General View From the Gardens.

ing and the fairy-like gardens, cost over \$100,000,000, which almost bankrupted the nation; in fact, this lavish expenditure of money was really one of the immediate causes of the Revolution, for the common people rightly objected to the king living in such luxury while only a few miles distant in Paris the multitudes were starving. In the huge palace the wonderful Room of Mirrors, the beautiful chapel, and the apartments of Marie Antoinette are in remarkable preservation. The principal facade is a French adaptation of the Ionic, with high Mansard roofs. The gardens which it faces are truly magnificent, being much larger than those at Hampton Court and planned on a more formal scale. Terrace rises above terrace; and looking down the

broad vista one sees rows of beautiful fountains, avenues of statues backed by trees and flowers, and farther still lagoons and artificial lakes that seem to vanish in one distant point. Once a month in warm weather the numerous fountains play, and in all directions are the shooting jets, some of which rise to a height of seventy-five feet. In a corner of the park are the two private homes formerly occupied by Marie Antoinette and Louis XVI.—the Grand and the Petit Trianons. And just outside the limits of the park, away from the extreme pomp and ceremony of the fashionable court, the child-like Marie built for herself the Village of Love—quaint, little, half-timbered dwellings, and a rustic stone mill and dairy with roofs of thatch. Here in the environment of a quiet, model farm she sought relief from the frivolities of the “madding crowd,” in grinding flour, baking her own bread, milking the cows, and feeding the chickens and ducks. And so the great Versailles—the last word in formal building—proved so grand and luxurious that it became unbearable to even a pleasure-loving queen.

Farther south, down in Provence, is a palace totally different from all others in France. There are in a few ancient cities places that seem to resume within themselves not merely the period of culture which they represent, but all the centuries which saw their greatest glory. Such a place is the Palace of the Popes in Avignon. Within that mighty mass of architecture, which served not only as a palace and a shrine, but as a fortress as well, lived seven Popes in the fourteenth and fifteenth centuries, and they made it the center of attention of all Europe. This somber, Gothic building is perched high up on a white rock in a remarkable defensive position. The massive pile, with its severe white stone walls, pointed arches with deeply shadowed reveals, and fortress-like detail, is most expressive; and looming, as it does, high up over the brown tile roofs of the town below, and with the bright blue, cloudless sky as a background, it makes a picture that is never forgotten. During one of the many Papal wars the palace was besieged for ten years, but with no visible damage resulting—indeed, nothing could spoil the effect of the exterior, with those mighty engaged arches which form the largest machicolations in the world, and through which the Pope's defenders poured molten metal and hurled missiles down on their assailants. Every gate is defended with a portcullis and every wall crowned with parapets. The rock cliff, from which this grandest and most awe-inspiring of all the historical monuments of France grows, plunges straight down into the river. What structure or setting could better express the Church Militant?

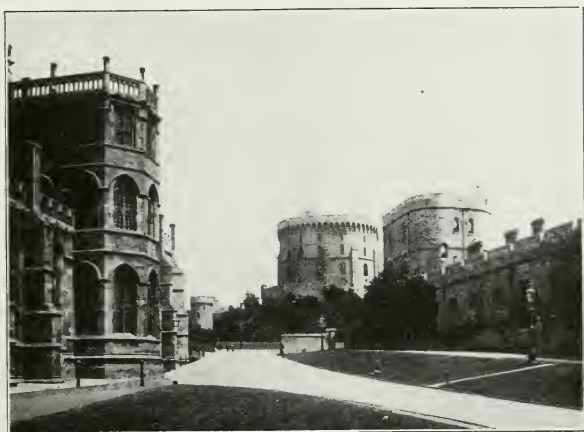
In Italy palaces are almost as plentiful as are buffets and cafes here in our land. Not only the many princes, dukes and nobles, but even the wealthy merchants and *bourgeois* built magnificent palaces in great profusion. After affairs became calmer in Italy the Popes left Avignon and took up their residence again in Rome. In the early sixteenth century Bramante began the construction of the new Papal palace known as the Vatican. Besides containing a wonderful art museum which is rivaled only by that in the Louvre, the Vatican is most interesting architecturally for its



A Room in the Apartment of the Borgias in the Vatican.

marvelous interior decorations. A series of rooms and loggi were decorated by Raphael and his school; and the apartments of the Borgias, where Lucrecia held sway and mixed poisons for a pastime, were done by Pinturicchio. The vaulted ceilings, with their rich colors and excellent detail, are magnificent, though somewhat gloomy and awful; and the painted canvas walls harmonize well with the general scheme. The well designed mosaic floors and large marble fireplaces add just enough contrast to keep the place from becoming uncanny. The paintings of Biblical characters on the walls and ceilings of the Sistine Chapel in the Vatican were executed by Michael Angelo, and are generally conceded to be the grandest creations of modern art.

More elaborate and regal than the king's palace in Rome is the royal residence in Florence—the famous Palazzo Pitti, which was begun by Brunelleschi by order of Luca Pitti, the powerful opponent of the Medicis, and his idea was to erect the most imposing palace ever built by a private citizen. The structure, which externally resembles to some degree a castle or prison, is remarkable for its bold simplicity, due to the severe fortress-like character of the rusticated masonry—but the courtyard and garden facade, in contrast with this stern exterior, seem light and cheer-



Rear View of the Pitti Palace and Part of the Boboli Gardens, Florence.

ful. The Pitti served as a model for the Luxembourg Palace in Paris, although the latter, with its high roofs and projecting pavilions, excels the Florentine structure in grace and picturesqueness. The Palazzo Pitti is nearly 500 feet long and is backed by the beautiful Boboli Garden, which extends in terraces up a hill from which a splendid panorama is had of Florence, with her domed cathedral, its adjoining Campanile, the picturesque River Arno, and the heights of the Piazzale Michelangelo, on which towers the colossal statue of David with sling in hand—a sentinel keeping watch over Italy's "City Beautiful."

STORAGE BATTERIES FOR SMALL CENTRAL STATION POWER PLANTS.

BY H. B. MARSHALL, E. E.*

Practically all of the central station literature of today is devoted to electric power plants in towns and cities having a population of more than 1,000 people. Until a short time ago an electric light plant in a town of less than a thousand people was not seriously considered. The last few years have seen a marked change in this condition, however, and complete plants have been and are being installed in towns of from 200 to 1,000 people. The number of these plants in service is increasing rapidly and as the neighboring towns become aware of the advantages which these towns are enjoying they will insist on obtaining the same advantages.

Most of the equipments which are being furnished for these small plants include a gas or gasoline engine, a direct current generator, a storage battery and the necessary switchboard.

Among the many reasons which may be mentioned as causing the rapid progress which has been made in this field are: (1) the improvements in gas engine design; (2) the advent of the high efficiency lamp, and (3) the realization of the many advantages of the storage battery when used in this class of service.

The gas engine has been developed to a point where it gives satisfactory results in central station service, with a comparatively small outlay for power. The number of engines in use of the small sizes required for these plants insures that they can be manufactured at a low first cost, and repair parts are carried in stock at the larger points, so that repairs can be taken care of very promptly.

The advent of the Tungsten lamp has also helped to make these plants a good commercial proposition. One of the chief objections to a plant of this kind is the first cost of the plant, and since the capacity required to give the same illuminating results is reduced by the substitution of Tungsten lamps for the old carbon lamps, a smaller plant will take care of the requirements, and the first cost will, therefore, be reduced.

A reduction in capacity of the station apparatus, made possible by the Tungsten lamp, applies even more markedly to the storage

*Class of 1905. Contract Agent, The Electric Storage Battery Company, St. Louis.

battery, so that it is now commercially profitable to utilize a storage battery to secure the advantages of 24-hour service with very little added expense for labor and fuel.

The plant should be so designed that the engine and generator will be of sufficient capacity to take care of the peak load in the evening and charge the battery at the same time. About midnight the engine and generator are shut down, the storage battery

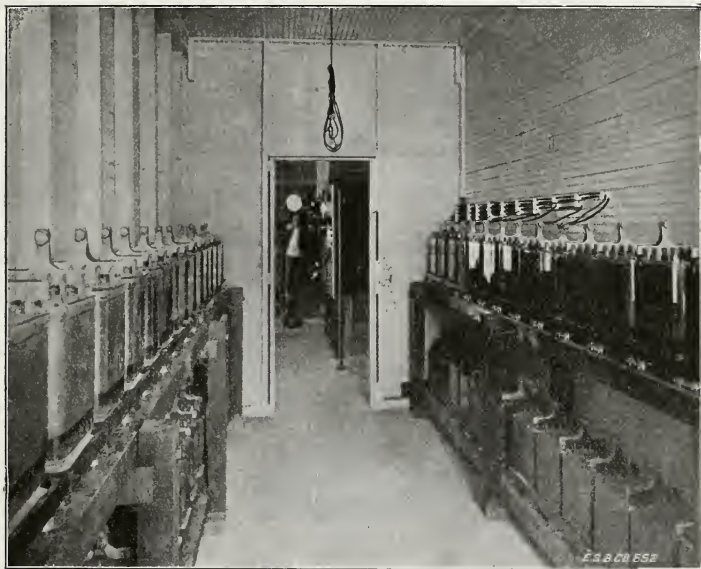


Fig. 1.

taking care of the load until dusk the next evening, when the same process is repeated. Since the plant is only in actual operation a few hours each evening it is only necessary to have an attendant at the plant at that time. The fuel actually required for charging the battery is very small, for it should be realized that if the battery were not being charged the gas engine would operate at a lower load and, therefore, at a lower efficiency and require almost as much fuel as when charging the battery.

Furthermore, as the load on the station grows it can be easily handled, using the entire generator capacity, if necessary, for carrying the peak and then running such additional time as may be necessary for charging.

Fig. 1 shows a storage battery of "Chloride Accumulator" cells used in the electric light plant at Remsen, Iowa. The use of the battery provides a full 24-hour electric service, so that it is only necessary to run the engine to charge the battery.

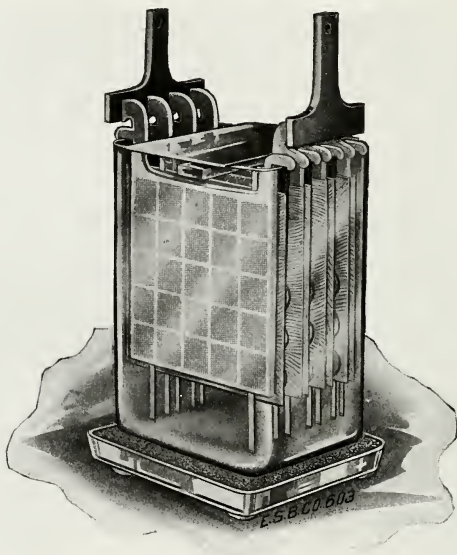


Fig. 2.

Many of the electric lighting plants in towns and cities of 1,500 or more people are designed for alternating current, and the conditions at these points usually warrant such an installation. It must not be assumed, however, that all central stations should use alternating current. Very often it is not realized by designers that the conditions existing in most of the towns having a population of 200 to 1,000 favor a direct current plant far more than they do an alternating current plant. The distances for transmission to the farthest points are usually short and well within the range of economical direct current distribution. If for

no other reason it is advisable in practically all of these towns to install direct current rather than alternating in order that the advantages to be gained by the use of storage batteries may be secured.

Taking up somewhat in detail the storage battery equipment for this class of service, the number of cells are determined by the desired voltage, each cell giving a voltage of approximately 2 volts on discharge regardless of the size of the cell, while the size of the cell determines the ampere-hour capacity of the battery. Each cell includes two sets of plates immersed in a solution of dilute sulphuric acid. The plates and acid for batteries of this size are usually contained in glass jars. The two sets of plates differ from each other in appearance, and in process of manufacture. The positive plate has a dark brown chocolate color, while the negative plate is a light gray or lead color. Fig. 2 shows a typical cell. The cells are connected in series; that is, the positive plates of one cell being connected to the negative plates of the adjacent cell throughout the entire battery.

The glass jars may be of the size to accommodate a number of plates originally installed, or they may be larger, allowing additional plates to be installed at some future time when additional battery capacity may be required. This allows the initial expense to be kept to a minimum and provides for increasing the capacity of the battery economically when occasion may require.

When the installation is for a bus voltage of approximately 110 volts, these batteries are ordinarily charged by connecting two halves of the battery in parallel, each through a fixed resistance across the 110-volt bus. With this method of charging the total apparatus required for the storage battery equipment is reduced to a minimum, and the attention required during charging is very little.

When conditions warrant the use of 220 volts rather than 110 volts the usual practice is to install a 220-volt 3-wire system with a 110-volt battery. When the battery is to take the load the generator is disconnected from the line and the two outside leads are connected together, these serving as one lead for the battery, the neutral serving as the other lead. This gives very satisfactory results, for it should be remembered that the maximum battery load will be very small compared to the peak of the system, and the line drop will, therefore, not be objectionable under this arrangement.

There are a large number of small direct current plants in service which were installed before the advantages of the battery

equipment were realized. A large number of these have since added the battery equipment. One of these was installed by the company owning the plant at Cambridge, Neb., several years ago. After the battery had been in operation about one year the entire plant was destroyed by fire. Not long afterward the town took over what was left and built a new plant. They had only enough money to get the plant without the storage battery. It was but a short time after they resumed operation, however, before they realized they must have the battery equipment and the final outcome was that a number of the business men of the town subscribed to a fund to purchase the battery, which fund was turned over to the town to be paid back in installments taken from the earnings of the plant. The town then installed an exact duplicate of the first storage battery of "Chloride Accumulators," and it may be of interest to know that this loan has now been entirely paid back from the earnings of the plant.



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ARMOUR INSTITUTE OF TECHNOLOGY.

VOL. V

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NO. 1

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or portions of same, provided proper credit is given.

In submitting the first issue of the fifth year of THE ARMOUR ENGINEER to its readers we beg to call attention to the new department under the heading of "Alumni Notes." During the years of its existence it has been the policy of the successive editorial boards to keep the publication from being what is commonly called a "family journal"; that is, they endeavored to make the publication attractive to all engineers, whether affiliated with

Armour Institute of Technology or not. Many requests for such a department have been made, however, and the present board realizes that since the *ENGINEER* is the publication *of* the student body it should also be the publication *for* that body. It is believed that the "Notes" will be read with interest by all Armour men, and to others they will give some indication of the quality and progress of our graduates. We aim to feature this department and solicit the co-operation of all alumni. Except for a number of contributed items, it has been possible to record only such changes of occupation and promotions as are given by the roster cards of the Alumni Association. While this serves its purpose, we wish the alumni would not be too modest, but send in items concerning their activities whenever they can.

We wish to thank the members of the faculty and the alumni who have contributed for this issue. For the time and study they have given in furnishing the real meat of the magazine it is only possible for us to offer them the assurance that their efforts are greatly appreciated by their Alma Mater, as is evidenced by the well wishes and compliments the *ENGINEER* has received.

It is seldom that a practical engineer takes enough interest in college students to give them three lectures in the course of a few weeks. However, such was the case at the Institute last fall, and the engineer in question was Mr. Victor Falkenau, of the Falkenau Construction Company, who gave a series of talks on "General Problems in Building Construction," particular reference being made to foundations. Mr. Falkenau drew from a fund of forty years' experience in the construction of buildings. His particular forte is the sinking of caissons, and while outlining the methods of construction he told of the difficulties the contractor encounters, and, of course, gave the solutions. His company, in 1893, sank the first caissons in Chicago. After one of his lectures he led the members of the Senior and Junior classes on an inspection trip through the Wrigley Building, Thirty-fifth street and Ashland avenue, a seven-story concrete factory building of the flat-slab construction.

Mr. Falkenau is very friendly toward A. I. T., and his generosity is appreciated by the students, for they realize that he is giving them the benefit of his practical knowledge.

We are in receipt of a pamphlet entitled "Light: Its Use and Misuse," a primer of illumination prepared under the direction of the Illuminating Engineering Society, 29 West Thirty-ninth street, New York City. The primer has been written especially for the general public. The text sets forth in a clear and understandable manner some of the general principles of light and illumination. The primer will serve to direct attention to the numerous evils attending bad lighting, and will create a desire for good illumination not only in the home and the office, but in the store, the mill and the factory.

The Illuminating Engineering Society was organized in 1906 to advance the theory and practice of illuminating engineering and to disseminate knowledge relating thereto. The society now has about 1,600 members who are interested in the subject of lighting from various standpoints: engineering, economic, hygienic, esthetic. The society has no affiliation with any commercial organization, and anyone interested in its objects may become a member.

The mid-winter reunion and banquet of the Alumni Association was held at the Hotel Sherman Friday, December 20, 1912. The attendance was considerably larger than in former years, plates being laid for 108. Mr. C. E. Freeman, '97, acted as master of ceremonies.

After the business of eating, the members were treated to an enjoyable and very interesting program. Prof. Montraville M. Wood gave a live-wire talk on "The Gyroscope," and illustrated his subject with stereopticon views and demonstrations. Prof. Wood is an aviator of experience and showed some of the applications of the gyroscope to the aeroplane. Mr. Charles C. Sampson, '04, gave an instructive talk on "Safety First," a subject of great interest to all engineers. He illustrated his points with pictures taken at the different plants of the Illinois Steel Company. The

methods inaugurated by that company for preventing accidents to employes have been highly successful; in fact, the South Chicago Works of the company was reported to be the safest steel mill in the world.

"Progress Reports by the Faculty" were next in order, there being no "Tales of Woe by the Alumni." Dean H. M. Raymond complimented the graduates on their loyalty, enthusiasm and get-together spirit. He reported general progress and improvement in all departments at the Institute, punctuating his remarks with local statistics and comments on the engineering educational situation throughout the country; also called attention to the new department of Industrial Arts, in which there are thirty students enrolled. Five-minute "Progress Reports" were given by Professors Campbell, McCormack, Gebhardt, Snow and Phillips, each from his department. Prof. Campbell said that he did not remember many of the names of the alumni present, but that he did remember their faces and most of the grades they made in Calculus. Prof. McCormack outlined the improvements made in the chemical laboratories during the past three years, and also stated that the Institute now has the first fireproof chemical laboratory in this country. Prof. Gebhardt spoke of what he called "the" department at Armour Institute and of the new refrigerating laboratory, which was erected during the past summer. Prof. Snow spoke of the progress in the electrical department, emphasizing the use of preliminary reports in the laboratories. Prof. Phillips' talk was on the civil summer camp and affairs in general pertaining to the civil department.

Mr. E. F. Hiller, '06, stated the purpose of the life memberships in the Alumni Association, explaining that the money obtained in this manner was used for loans to needy students at the Institute, and invited graduates to become life members.

The meeting was then adjourned.

During the past year much has been done by the corresponding secretary of the Alumni Association to systematize and complete the list of alumni members. Several weeks before the mid-winter banquet over 800 letters were sent out by the Association,

and but 25 were returned unopened. Some 300 answers were received. The remaining members are urged to send in their roster cards as soon as possible.

Below is a list of members whose addresses are unknown, and anyone knowing the location of any of these men will confer a favor on the Alumni Association by supplying the address.

Olson, E. H.....(E) '99	Sanders, W. J.....(E) '07
Twitchell, F. W.....(E) '99	Stanton, Gustav, Jr....(C) '07
Hausman, Herman....(E) '00	Tompkins, G. D.....(C) '07
Eustice, C. E.....(E) '01	Holmboe, Ralph.....(C) '08
Harwood, F. T.....(E) '02	Matthei, H. R.....(C) '08
Persons, V. S.....(C) '02	Meyer, G. J.....(C) '08
Kaempfer, Albert....(E) '03	Pacyna, Arnold.....(Ch) '08
Rawson, H. B.....(E) '03	Thomson, F. L.....(Ch) '08
Stillson, H. G.....(E) '03	Wolters, G. F.....(A) '08
Weisskopf, M. J.....(C) '03	Bexton, L. N.....(E) '09
Collins, F. L.....(E) '04	Ebert, A. A.....(C) '09
Coy, F. A.....(C) '04	Ecklund, C. A.....(C) '09
Knapp, Morris J.....(E) '04	McAuley, E. F.....(M) '09
MacMillan, A. W.....(M) '05	Megahy, J. E.....(C) '09
Snowden, C. R.....(E) '05	Urson, F. J.....(C) '09
Cutler, E. W.....(E) '06	Cole, V. E.....(C) '10
Edson, N. L.....(M) '06	Clarkson, Wm., Jr....(C) '10
Morrison, Ralph D....(M) '06	Zeisler, L. T.....(E) '10
Nicholson, Victor....(Ch) '06	Doering, R. C.....(FP) '11
Pierce, F. T.....(C) '06	Hynes, P. R.....(C) '11
Reynolds, M. B.....(C) '06	Szeszycki, I.....(C) '11
Nelson, C. J.....(C) '07	Williams, L. L.....(E) '11

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The Armour Institute of Technology Branch of the American Institute of Electrical Engineers exists for the purpose of giving the electrical student an opportunity to hear and meet prominent men engaged in engineering work, and enables him to prepare and discuss papers on technical subjects.

The first regular meeting of the college year was held Sept. 25, 1912. As no definite program had been arranged the chairman called upon members to address the society. Several members of the faculty responded with interesting talks on the purpose of the A. I. E. E., and of the advantages to be derived from it by the students. A number of the students told of their experiences in electrical work during the summer.

The second meeting was held Oct. 22, 1912. Mr. A. L. Arenberg read a paper on "Storage Batteries." A detailed description of the various types of storage batteries and their uses was given. The process of charging batteries was described and the various theories of the chemical reactions involved were discussed. An interesting discussion followed the reading of the paper.

The first November meeting was held on Nov. 6, 1912. Mr. T. H. Pither gave an illustrated talk on the "Commercial Application of Lifting Magnets." Many interesting points in the design and construction of the magnets were brought out, and details of the construction were shown on lantern slides.

The first December meeting was held Dec. 5, 1912. Mr. P. Copenhaver presented a paper on "The Application of Electricity to the Gasoline Automobile." The paper gave a detailed description of the various electrical systems used in up-to-date automobiles. The different kinds of self-starters now employed were explained with the aid of wiring diagrams and illustrations. A very lively and interesting discussion followed.

The Society held its semi-annual banquet at the Boston Oyster House on Dec. 18, 1912. Following the dinner Mr. G. E. Marsh presented a paper on "Transmission of Power by Direct Current." A detailed description of the direct current transmission systems used in Europe was given. A comparison of the alternating current system and the direct current system as to their advantages and disadvantages brought out many interesting points. This very instructive paper was followed by rather lengthy discussion.

—R. L. Walsh.

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The Armour Institute Student Branch of the American Society of Mechanical Engineers opened the year with its annual smoker on Sept. 19, 1912. This afforded the Seniors an opportunity of becoming acquainted with the new Junior members, and the latter of meeting members of the faculty in a social way. It has been pointed out at various times that membership in the student engineering societies is of great value to the undergraduate, since it brings him in touch with the engineering profession. This is further emphasized by the announcement that the committee of the council on student branches of the A. S. M. E. has been increased by the appointment of Prof. William Kent, whom we all know as the editor of *Kent's Handbook*. The membership numbers thirty-three, but this figure has always been exceeded by the attendance of members of the faculty and visitors.

On Oct. 9, 1912, the society held its first meeting in conjunction with the local branch of the American Institute of Electrical Engineers. The evening was devoted to the lecture of Mr. C. K. Baldwin, member of the A. S. M. E., who spoke on "Belt Conveyors." After a brief history of conveyors in general, the belt conveyor was described and illustrated by numerous lantern slides. This subject is a comparatively new one, of great commercial importance, and hence was appreciated accordingly.

At the second meeting, on Nov. 6, 1912, Mr. Daniel Roesch, '04, instructor in Experiment Engineering at the Institute, addressed the Society on "Carburetors and Mixing Valves." Mixing valves for gas engines, as well as various types of automobile carburetors, were discussed at the conclusion of the talk. Having acted in the capacity of operating engineer for a number of years, Mr. Roesch was able to bring out points of practical interest.

The last meeting of the year was held on December 4. Mr. S. Rosenzweig, of the Erie City Iron Works, Erie, Pa., presented a paper on "Poppet Valve Engines and Superheated Steam." Illustrating his remarks by means of fifty slides the speaker described the Lentz poppet valve steam engine, which is especially designed to operate under the high temperatures produced by superheated steam. A general discussion followed, in which several members of the faculty and students took part. Superheated steam is used to a greater extent in Europe than in this country, and in Germany some remarkable steam economies have been obtained.

—H. R. Kuehn.

THE CIVIL ENGINEERING SOCIETY.

The first meeting of the Society was held in the Engineering rooms on Oct. 1, 1912. Prof. A. E. Phillips was the first speaker of the evening, and gave the students valuable advice in regard to engineering in general. Mr. J. C. Penn was the next speaker. He gave a short talk on "The Value of Comradeship to the Student." After this interesting talk President Cramer called on Professors Dean and Armstrong for a talk. They both responded readily and were appreciated by the members. The evening as a whole was thoroughly enjoyed by all, and was a good beginning for what will probably be the most prosperous year of the Society.

On October 15, the Junior candidates for membership in the Society were initiated. The initiation, in the form of an oral examination, was tried, and proved very successful. The Engineering rooms proved too small to accommodate comfortably the alumni and members who attended this event. After the examination came the "smokes" and "eats." The evening was probably the most enjoyable of any social event ever given by the Society.

On November 19 the second lecture of the Society was held in the Engineering rooms. Mr. E. L. Saner gave an illustrated talk on "Pure Water Supply." This talk, coming from one closely identified with the subject, was surely well worth hearing, as Mr. Saner forcefully showed its connection to the health of the people.

On December 3 Mr. H. E. Bartlett gave a paper on "Engineering as a Profession." In the course of his lecture he laid great stress upon the value of good common sense and judgment, together with a theoretical knowledge of his profession, to the embryo engineer. He especially emphasized the fact that neatness, frankness and personal appearance were indispensable to the graduate student in applying for an engineering position.

On December 17 the Society held its last meeting of the year. Mr. Ball, who was to be the speaker of the evening, was called out of the city, and Professor Wells of the Civil Engineering Department gave an illustrated talk on "The Viaduct of the Santa Fe & Missouri Bridge of the St. Paul Railway." This lecture was enjoyed by all present.

Notwithstanding the fact that all of the meetings of the Society were well attended, the Society has decided to invite the Sophomore Civils to attend the meetings. The Sophomores are desired as guests, and it is hoped they will take advantage of the offer of

the Society and attend the meetings regularly. By this means they will get a good insight into the work of the Society and will know what to expect of the Society when they become eligible for members as Juniors. The Society also extends the same hearty welcome to the alumni, and it is hoped they will attend and become acquainted with the present members and meet their old classmates.

—*Henry F. Israel.*

THE SENIOR CHEMICAL SOCIETY.

On May 15, 1912, the graduating Chemicals called a meeting, at which the officers for the present school year were elected. The officers are: W. K. Munn, president; Fontenelle Moore, vice-president; R. S. Ziehn, secretary, and W. C. Buttner, treasurer.

The first banquet of the year was held October 16, at Kunz-Remler's. Prof. McCormack, the speaker of the evening, gave a very interesting talk on the Eighth International Congress of Applied Chemistry. At the close of the talk an informal discussion was held, as is the custom at the banquets of this society. Twenty-six members were present.

The second banquet was held at the Chicago City Club, November 20. Mr. Clarage, who intended to address the members, was unable to attend. Prof. McCormack told some interesting facts in regard to the adaptability of chrome-nickel steel to the manufacture of non-corrosive pocket-knives and cutlery in general. Prof. McMullen gave an interesting and instructive talk on the evaporation and treatment of eggs and methods of subduing the attendant difficulties in trying to keep the product soluble. The attendance was small, but all present spent a very profitable evening.

The annual alumni dinner has been set for January 15, 1913, and will be held at the Sherman Hotel. It is expected that all the professors and many of the alumni will be present. There will be at least three speakers at this banquet.

—*R. S. Ziehn.*

THE ATELIER.

The graduating classes in the architectural department are increasing yearly. The 1913 architects number fifteen, and the Juniors promise to exceed this number. This rapid increase in the classes is in great measure due to the combined efforts of the

faculty. The new course in construction has strengthened the department.

The Armour Architectural Library has received a donation of \$50,000 from the late D. H. Burnham. There are few more worthy causes.

Mr. Alder, a graduate of Massachusetts Institute of Technology, is the new addition to the faculty. He has already "won a home" with both his own class—the Freshmen—and the Senior "constructionists." Mr. Alder is the third "Boston Tech" man to cast his lot with the Atelier.

As usual, the Home Traveling Scholarship is open to both Seniors and Juniors. The problem this year is "A Roman Catholic Cathedral." A number of the Seniors will make the trip to Europe the coming summer, regardless of their success or failure with the scholarship prize.

—*J. B. Lindquist.*

ALUMNI NOTES.

1897.

Russell Calkins of the class of 1897 has bought alfalfa land near Elsinore, Cal., and is living in Riverside, Cal.

Charles S. Buell of the class of 1897 is in the engineering and contracting business, with offices at 1641 Monadnock Block, Chicago.

1898.

E. G. Hindert is engineer with the Public Service Company, at Waukegan, Ill.

H. A. MacClyment is a member of the firm of Inglewood Brick Company, Los Angeles, Cal., and he would be glad to hear from any alumni members in Southern California.

J. M. Humiston of the class of 1898 is connected with the Chicago Telephone Company as facilities engineer.

1899.

S. C. Fiddymont is doing some experimental work on screw presses. He was one of the "old timers" at the mid-winter banquet.

C. T. Lewis, formerly with the Link Belt Company, Chicago, is now mechanical engineer for the Labor Saving Device Committee of the Hawaiian Sugar Planters' Association at Honolulu, and is engaged in the work of designing and perfecting special machinery for harvesting sugar cane, to meet the peculiar conditions found in the islands.

L. F. Mahler is manager of the Universal Shoe Machinery Company at St. Louis, Mo.

H. S. Powers has become a member of the firm of Spencer & Powers, at 10 South La Salle street, Chicago.

1900.

L. C. Bradley passed away suddenly on the 28th of June, 1912, his death being caused by accidental drowning at Waukesha Beach, Wis.

C. A. Garcelon, Jr., is vice-president of the West Oxford Telephone Company at North Lovell, Me.

F. P. Walther is with the Continental Fire Insurance Company of New York City.

1901.

Louis Cohen has recently severed his connection with the National Electric Signaling Company, where he was chief of the research department and also had charge of the Brant Rock station. He is now engaged temporarily in carrying on some private researches in wireless communication at the College of the City of New York, experimenting with the Poulsen set which was presented to the institution by Mr. Gano Dunn, past president of the A. I. E. E. Prior to becoming associated with the National company, Mr. Cohen was connected for four years with the National Bureau of Standards, some of the publications of which appeared under his authorship.

W. R. Ruegnitz is chief inspector with the Continental Insurance Company at Chicago.

J. B. Swift, Jr., is connected with the sales department of the Dodge Manufacturing Company of Chicago.

1902.

I. D. Miller is now inspector and draftsman in the bridge department of the Chicago & Northwestern Railway and stationed in Chicago.

B. K. Postlethwaite is superintendent of the Baker Valve Company at Minneapolis, Minn.

L. A. Sanford has severed his connection with the Miehle Printing Press and Manufacturing Company and is now with the Indiana Steel Company.

1903.

J. E. Lanning has been appointed construction engineer of the Inspiration Consolidated Copper Company, Miami, Ariz. His appointment became effective January 1. Mr. Lanning was formerly contracting engineer with the Minneapolis Steel and Machinery Company.

E. D. Merry was a caller at the Institute on registration day. He is superintendent of the Pontiac Light Company, Pontiac, Mich.

E. F. Nelson is now with the Westinghouse Electric and Manufacturing Company at East Pittsburg, Pa.

C. P. Phillips is architectural engineer at 3400 Center avenue, Chicago.

On December 20, 1912, W. S. Taussig addressed the students of Syracuse University, College of Forestry, Syracuse, N. Y., on "Electricity in the Lumbering Industry."

1904.

Arthur Buie died September 3, 1912, at his home, 433 Sixtieth street, Englewood, Chicago, after being disabled over four years as the result of a fall.

L. J. Bryne, formerly with the Insurance Survey Bureau, Chicago, is now manager of the Illinois Agricultural Chemical Company, Monadnock Block, Chicago.

1905.

J. C. Brackett has severed his connection with the Tennessee Copper Company, Copper Hill, Tenn., and is now with the Canadian Copper Company, Ontario, Can.

R. H. Fash is chief chemist for the Chickasha Cotton Oil Company, Chickasha, Okla.

G. P. Lennartz is now mechanical engineer with Woodmansee, Davidson & Sessions, Chicago.

F. C. Clark has been with the Isthmian Canal Commission since June, 1909, as assistant engineer, as supervisor of electrical inspection, and now as assistant superintendent of erection in charge of installation of permanent electrical equipment for the operation of locks and spillways at the canal.

H. M. Sharp is vice-president and general manager of the Kelly Construction Company, Bryan, Ohio. He would like to hear from W. C. Mathews, '03.

J. K. Thompson is superintendent of construction with the Falkenau Construction Company, Chicago. The Wrigley Building, at Thirty-fifth street and Ashland avenue, a seven-story concrete building of the flat-slab construction, to which the members of the Junior and Senior classes of A. I. T. paid an inspection visit last fall, is under his supervision.

F. B. Whitney is now in the engineering department of the Peoples Gas Light and Coke Company, Chicago.

1906.

F. J. Flanagan is connected with the Harbor and Subway Commission, City of Chicago. He recently became a benedict.

C. C. Hotchkiss is assistant superintendent of the testing laboratory, Peoples Gas Light and Coke Company, and is largely engaged in the application of chemical control to the operation of gas producing systems, particularly water gas.

G. W. Kuhn, formerly with the Chicago Telephone Company, is now telephone engineer with the American Telephone and Telegraph Company, New York City.

G. W. Smith is now a member of the firm of Lindsey & Smith, general contractors, Dallas, Tex.

H. L. Strube is with the Link Belt Company, Chicago.

R. S. Torrance has resigned as general superintendent of Kohler Bros., and is now secretary and treasurer of S. R. Fralich & Company, Chicago.

F. N. Wilson is president of the Wilson Machinery Company, Chicago.

1907.

L. H. Badger has returned from the Philippines and is in the engineering department of McGuire-Cummings Manufacturing Company, Paris, Ill.

A. H. Boehmer is engineer in the construction department of the Otis Elevator Company, Chicago.

C. S. Henning is engineer in Madera, Chihuahua, Mexico.

H. W. Jarow of the class of 1907 is sales manager with the Diamond Power Specialty Company, Detroit, Mich.

H. W. Jones is now chief chemist with the Wm. S. Merrell Chemical Company, Cincinnati, Ohio.

J. C. Matchett, formerly with the McCrum-Howell Company, Chicago, is now with the Illinois Engineering Company, Chicago.

E. A. Pratt is civil engineer with the Trussed Concrete Steel Company. His present address is Mount Road, Mazagon, Bombay, India.

W. H. Reker has resigned his position with the Bryan-Marsh Company, and is manager of the Tungsten Maintenance Company, Minneapolis, Minn.

J. T. Walbridge is supervising the construction of a levee along the banks of the Mississippi River at Peoria, Ill.

1908.

H. R. Badger, formerly with the Hoskins Manufacturing Company, Detroit, is sales efficiency engineer, 908 Mutual Life Building, Buffalo, N. Y.

D. O. Barrett has resigned his position as superintendent of the Manitoba Windmill and Pump Company, Brandon, Man., and is now chief engineer of the Hew Engine Company, Portsmouth, Ohio.

A. A. Dittmar is building superintendent of the H. R. Wilson Company, Chicago.

H. S. Ellington, former treasurer of the Alumni Association, has resigned as engineer and superintendent, Standard Concrete Construction Company, Chicago, and is now superintendent of construction, Stroh Brewing Company, Detroit.

H. W. Nichols is teaching "Electrical Measurements" to the Sophomores of A. I. T. and has charge of the Junior electrical laboratory course, succeeding Prof. G. E. Marsh. The former is also teaching the Seniors "Electric Railways." Mr. Marsh has taken the place of Prof. W. E. Barrows, who is now head of the Electrical Engineering Department at the University of Maine. Mr. J. J. Gilbert, who comes from the University of Chicago, has charge of the work formerly done by Prof. Nichols.

C. S. Packer is now with George Enos Throop, Inc., Chicago.

R. A. Perkins is in the contracting business at Sioux Falls, S. D.

R. L. Stevens is acting Assistant Professor of Civil Engineering, University of Washington, Seattle.

C. L. Zimmerman has changed from the engineering department, Chicago & Northwestern Railway, to the Department of Public Improvements, City of Omaha.

1909.

K. M. Boblett, who has been in the automobile radiator manufacturing business since graduation, has one patent issued and three patents pending on automobile radiators, also one patent pending on an automatic radiator making machine; all due to the heavy hitting of the A. I. T. faculty. This is an example of perfecting an idea and then hanging on to the finish.

A. C. Buckett is an architect at 1417 Railway Exchange, Chicago.

E. B. Crane is now with the Mahoning & Shenango Railway and Light Company, Youngstown, Ohio.

J. E. Fitch is practicing law, with offices at 1334 Stock Exchange Bldg., Chicago.

E. K. Hammond has been appointed to the position of associate editor of *Machinery*, New York City. Mr. Hammond was formerly on the editorial staff of *Modern Machinery*, Chicago.

George Hirshfield, formerly with the Illinois Steel Company, is now with W. A. Baehr, Consulting Engineer, Chicago.

C. M. Lindsay is now with the Hotpoint Electric Heating Company, Ontario, Cal.

J. I. Menkin has severed his connection with the Linde Air Products Company, East Chicago, and is president of The Sani-genic Company, Winnipeg, Can.

A. A. Perrine has resigned as Instructor in Electrical Engineering at Marquette University, Milwaukee, and is now manager and treasurer of the Quenemo Telephone Company, Quenemo, Kan.

E. W. Petty is now with the Cuthbert Electrical Manufacturing Company, Chicago.

Herbert Rose has been employed as engineer by the Federal Light and Traction Company of New York and is now in the western territory on design and construction work pertaining to the public service properties of the above company at Trinidad, Col.; Las Vegas, N. M.; Albuquerque, N. M.; Tucson, Ariz.; Deming, N. M., etc.

Milton C. Shedd is superintendent of the Southwestern Iron and Wire Works, El Paso, Tex. He complains that he has only seen two alumni in three years and a half and wishes he could see more.

T. W. Simpson is consulting industrial engineer at Grand Rapids, Mich.

Marinus Vanderkloot has left Swift & Company to become chief chemist of Darling & Company, Chicago.

F. C. Van Etten, who was chief electrician, Rock Island Arsenal, Rock Island, Ill., is with the Public Service Company of Northern Illinois, Home Insurance Bldg., Chicago.

J. M. Valerio is representative of the Western Electric Company at Rome, Italy.

1910.

I. N. Baughman is with the D. F. Murray Manufacturing Company, Wausau, Wis.

A. L. Bergbom is now in the engineering department of Chicago, Milwaukee & St. Paul Railway, Ortonville, Minn.

Henry J. Bremers, Jr., is assistant to the Water and Light Commissioner, Fremont, Neb.

R. G. Eliel is with the Chicago, Milwaukee & St. Paul Railway, 63 E. Adams, Chicago.

J. G. Hatman, F. O. Godfrey and E. M. Ruede, all of the class of 1910, have entered the consulting engineering field under the firm name of Hatman & Godfrey, with offices at 211 Midland Bldg., Kansas City, Mo.

W. K. Howenstein is an architect at Saskatoon, Saskatchewan, Can.

W. A. Kellner, who was with the Mead, Morrison Company, Chicago, is with the Chicago, Milwaukee & St. Paul Railway, Chicago.

J. D. Livermore is draftsman with Von Holst & Fyfe, Chicago.

R. S. Kloman has resigned his position with the Pere Marquette Railway. "Dutch" is now employed by the South Park Commission, Chicago.

E. F. Pohlman is chemist with the Peoples Gas Light and Coke Company, Chicago.

O. L. Richards, who has for the past year held the position of salesman for the Clay Products Company, Chicago, has recently severed his connection with that company and entered the advertising department of the United States Tire Company as special representative, with headquarters in New York City.

M. A. Smith, Jr., who was in the sales department of the Corrugated Bar Company at St. Louis, Mo., is now district manager of the Haslett Spiral Chute Company, Chicago.

F. E. Wernick is now with the Syracuse Chilled Plow Company, Syracuse, N. Y.

1911.

C. W. Binder entered into partnership on December 15, 1912, with A. C. Berry under the firm name of A. C. Berry & Company, architects, with offices located at 206 Ruff Bldg., Hammond, Ind.

Hymen Bornstein, who was chemist with the Commercial Testing and Engineering Company, is now with Swift & Company, Chicago.

P. L. Bradford is test engineer with the General Electric Company at Erie, Pa. Mr. Bradford is in the gas engine testing laboratory, where the engines with their generators for the gas electric cars get their first taste of gas under his hands.

T. G. Cleaver is with the Witherspoon-Englar Company, Monadnock Block, Chicago.

G. C. Emmons is sales engineer with A. Sorge, Jr., & Company, Chicago.

J. G. Fenn is factory inspector with the London Guarantee and Accident Company, Chicago.

J. B. Johnson, who was with the Chicago Great Western Railway, is now concrete designer with the Chicago, Milwaukee & St. Paul Railway, Chicago.

O. K. Kellner is with the Chicago, Milwaukee & St. Paul Railway, Chicago.

P. F. Miller is sales engineer with the Pacific Flush Tank Company, Singer Bldg., New York City.

A. M. Newhouse, formerly with Sargent & Lundy, is with J. B. Hewitt & Company, Chicago.

A. H. Packer is assistant engineer in the automobile department of the Staver Carriage Company, Chicago.

E. O. Mandler is with the Chicago, Milwaukee & St. Paul Railway, Chicago.

G. E. Williams is chief electrician with the Proctor Water and Light Company, Proctor, Minn. He was married November 17, 1912.

1912.

S. C. Anderson is with the Chicago, Milwaukee & St. Paul Railway, Chicago, in the engineering department.

Graham Armstrong is in the operating department of the Commonwealth Edison Company, and is also teaching a class in electricity at the Englewood High School.

R. C. Armstrong is in the engineering department of the Public Service Company, Chicago.

W. E. Beach is civil engineer with the Chicago & Northwestern Railway at Curran, Ill.

A. J. Beerbaum is continuing his work with the Arnold Company, Chicago.

H. A. Bohlander is in the experimental engineering department of the Stromberg Motor Devices Company, Chicago.

R. B. Clark is with the Hardinge Conical Mill Company, New York City.

R. S. Claar is assistant chief draftsman with the Duluth, South Shore & Atlantic Railway, Duluth, Minn.

C. W. Collins is with the Aetna Engineering Bureau, Chicago.

T. Enoshita left for his home in Kobe, Japan, the first part of December.

G. C. Erickson is with the Illinois Northern Utilities Company, Dixon, Ill.

R. J. Geisler is assistant engineer with the Chicago, Milwaukee & St. Paul Railway at Delmar Junction, Iowa.

F. G. Hazen is draftsman in the engineering department of the Southern California Edison Company, Los Angeles, Cal.

E. C. Holden is with the Chicago, Milwaukee & St. Paul Railway, Chicago.

Sidney Kahn is chemist with Frensdorf & Brown, Baltimore, Md.

F. A. Graham is in the operating department of the Public Service Company, Blue Island, Ill.

P. M. Leichenko is architectural engineer with R. S. Lindstrom, architect, Chicago.

H. A. P. Langstaff resigned his position with the Sanitary District and is back in Winnipeg, Can., as voltage inspector of the Winnipeg Electric Railway.

G. D. Lewis is with the Chicago, Milwaukee & St. Paul Railway, Ottumwa, Iowa.

W. G. Martin is with the National X-Ray Reflector Company, Chicago.

P. L. Keachie is with the Studebaker Company, Detroit.

E. E. Piper has the honor of being the first graduate from the new course in Industrial Arts.

E. P. Roleson is selling conduit for the Circular Loam Company, Chicago.

L. H. Roller is with Brill & Gardner, engineers, Chicago.

R. R. Ross is service inspector with the Omaha Electric Light and Power Company.

J. J. Schommer has become a member of the faculty in the Chemical Department of A. I. T., and in addition is keeping Armour to the front in athletics by his excellent coaching.

D. A. Whitaker is in the engineering department of the Public Service Company, Chicago.

H. T. Yoshida is motor car draftsman with the Sheffield Car Company, Three Rivers, Mich.

Members of the 1912 class who have become benedicts are F. C. Dierking, N. F. Kimball and L. H. Roller.



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MAY, 1913

NUMBER 2

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The Armour Engineer

VOLUME V

MAY, 1913

NUMBER 2

THE NEW PLANT OF THE BUSCH-SULZER BROS. DIESEL ENGINE CO.

BY A. J. BEERBAUM.*

The Busch-Sulzer Bros. Diesel Engine Co., who are the exclusive licensees in the United States of Dr. Rudolf Diesel, inventor of the Diesel Heavy Oil Engine, are now completing their new plant at St. Louis, Mo. The buildings were designed by The Arnold Company of Chicago and are being constructed under their superintendence.

The new plant is located in the southern part of the city, about a quarter of a mile from the Mississippi River, one corner of the grounds being at the intersection of Utah and Second streets. The site occupies an area of about eight and one-third acres and the original surface of the ground slopes from an elevation of 70 feet at the southwest corner to about 20 feet at the northeast corner. The block plan is shown in Fig. 1 and a perspective view of the plant, looking southeast, is shown in Fig. 2. The present buildings are in two groups, the northern group consisting of the office building, service building, pattern storage building and the power house; and the southern group consisting of the machine shop, erecting shop, forge shop, oil house and a small pumphouse. The white lines in Fig. 2 indicate the future extensions of the present buildings, while the buildings shown in phantom in the background are future buildings. The extensions are also shown in Fig. 1.

Machine and Erecting Shops.

The machine shop, erecting shop, finished material storage and raw material storage form one building as shown in Fig. 1. The concrete foundation walls extend 3 feet 3 inches above the first floor line (elevation 37.75 feet), forming a 2-inch water table. The brick work is of the same design on all the buildings, the color being a dark brown and the mortar joints raked to a depth

*Class of 1912. With The Arnold Company, Chicago.

of about $\frac{3}{8}$ inch, causing the bricks to be clearly defined. The top of the walls are capped with "algonite" coping and all the pilasters are 4 feet wide. See Fig. 3. The columns of all the buildings are spaced at 21-foot centers (Fig. 4).

The machine shop is 211 feet long between column centers and two bays wide, the machine bay being 64 feet and the balcony bay 42 feet. The bottom of the truss is 40 feet above the floor

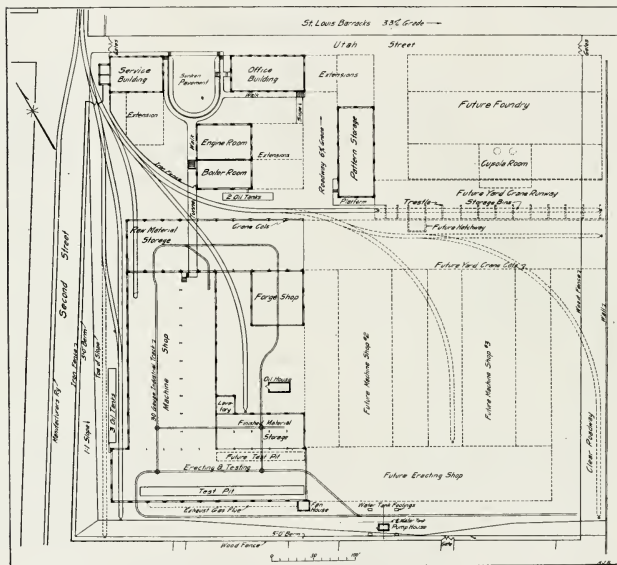


Fig. 1. Block Plan.

and the balcony floor is 26 feet above the main floor. The machine bay has a monitor 31 feet 6 inches wide by 8 feet 2 inches high and the balcony bay monitor is 10 feet 6 inches wide by 7 feet 4 inches high. The finished material storage is 105 feet long by 42 feet wide and is three floors high. The erecting shop is 231 feet long between column centers and 63 feet wide. The bottom of the truss is 44 feet above the floor and the monitor is of the same dimensions as that of the machine bay. The east wall is temporary and built of steel framing and asbestos-cov-

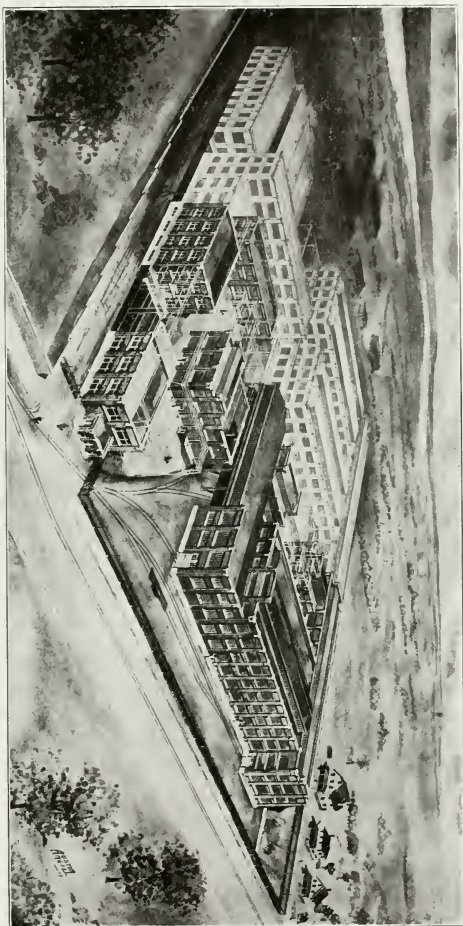


FIG. 2. Perspective View of Plant, Looking Southeast.

ered corrugated steel. The raw material storage is sheltered on the western side, and for a distance of 63 feet on the northern side, the appearance being like that of the machine shop. For the remaining distance of 147 feet the northern side is open to the height of rail of the crane runway, about 22 feet, and above this there is glass to the roof. The roof extends the entire length of the crane runway for 210 feet.

The roofs are of 1½-inch cement tile fastened to 9-inch I-beam purlins and covered with composition roofing. The main floor is of 5-inch concrete, finished with 1-inch asphalt in the erecting shop and with 3-inch creosoted blocks in the machine shop. The 4½-inch reinforced concrete floors of the second and third



Fig. 3. Western End of Machine and Erecting Shops.

stories of the finished material storage have a cement finish and the balcony floor of the machine shop has a 1-inch asphalt finish.

All the windows are of United Steel sash and ribbed glass. The windows of the monitors are provided with continuous sash operators, while the main windows are operated in sections.

On the main floor of the machine shop are the heavy machine tools and on the balcony are the lighter tools. All the tools are individually motor-driven. There is a tool room on the main floor under the balcony and one on the balcony, the partitions being 8 feet high and constructed of angle framing covered with sheet metal to a height of 4 feet 6 inches; above this is wire mesh.

The erecting shop is provided with a test pit (Fig. 5) 12 feet wide by 199 feet long and about 3 feet 6 inches deep. Along

the entire length of the pit run two cast iron rails, to which the engines under test are attached. Along one side of the pit runs the 6-inch water main, from the pump house, with 18 2½-inch outlets for connection to the water brakes and engine jackets. The outlet water drains into a 12-inch gutter running the full length of the pit and connects at the east end with the 8-inch pipe returning to the pump house sump. The exhaust gases from the engines are conducted to a concrete flue 4 feet 2 inches high by 3 feet 9 inches wide inside running underground along the south wall of the erecting shop and parallel to the test pit (Fig. 5).



Fig. 4. Structural Steel for Machine and Forge Shops.

This flue terminates at the east end in a concrete fan house (Fig. 6) 14 feet 3 inches long by 11 feet 7 inches wide inside with the floor at elevation 34 feet. A motor-driven, 80-inch three-quarter-housed Sturtevant fan placed in the house exhausts the gas from the flue and discharges it up a 3-foot steel stack running up through the 2½-inch reinforced concrete roof and in front of the corner pilaster to a height above the roof of the erecting shop.

The oil supply for testing the engines is drawn from three cylindrical tanks, each 8 feet 6 inches diameter by 29 feet 6 inches long and of 12,000 gallons' capacity. These tanks are encased in concrete and set below the ground on the western side of the machine shop.

The machine shop and raw material storage are each equipped with a 30-ton electric traveling crane of 60-foot span, and the

machine shop also has a $7\frac{1}{2}$ -ton crane with 39-foot span running underneath the balcony floor. The erecting shop has a 40-ton crane with a 60-foot span. These cranes are furnished by Pawling & Harnischfeger. The erecting shop is also provided with three 5-ton electric bracket cranes of the Whiting Foundry Equipment Company, traveling along the south wall over the test pit and under the 40-ton crane. Transportation is also provided for by means of industrial cars running on 30-inch gauge tracks between the machine, erecting and forge shops and the raw material storage. The finished material storage is provided with a 2-ton freight elevator.

The machine and erecting shops have flaming arc lamps for general illumination and carbon lamps for the drop lights over the tools.

Forge Shop.

The forge shop has structural steel framing and is 66 feet by 65 feet outside the brick pilasters. The height to the bottom of the truss is 23 feet, and the monitor is of the same size as that of the erecting shop. The south wall is a temporary one, built of steel framing and asbestos-covered corrugated steel, similar to the east wall of the erecting shop. The floor is of 8-inch tamped cinders and the roof is of $1\frac{1}{2}$ -inch cement tile fastened to I-beam purlins and covered with composition roofing. The building is lighted by flaming arc lamps.

Oil House.

The oil house is 26 feet by 12 feet outside the brick walls, which are 13 inches thick. The walls are built upon a concrete base, with a 2-inch water table extending 18 inches above the ground. The gable roof, with a pitch of 1 in 12, is of hy-rib and cement plaster, 3 inches thick and covered with composition roofing. The roof rests upon concrete beams, the bottom of which are 8 feet 9 inches above the floor. The 6-inch concrete floor drains toward a sump, 16 inches by 16 inches by 18 inches, in the center. There is a steel door, 3 feet 6 inches by 7 feet, at the west end. At the northeast corner of the house is a pit 2 feet 6 inches square by 3 feet deep, in which are placed the pressure reducing valve and steam trap for supplying and draining the $1\frac{1}{4}$ -inch pipe coil running along the floor and end walls. At the eastern end of the house is a fire extinguishing apparatus, consisting of a barrel of calcium carbonate with a bottle of sul-

phuric acid secured in the top. In case of fire a fusible link releases a rod which closes the vent in the roof and also breaks the acid bottle, thus causing the house to be filled with carbon dioxide.

• Pattern Storage Building.

The pattern storage building is 108 feet by 44 feet outside the brick pilasters and consists of two stories and a basement. The frame work is of concrete with the Kahn system of reinforcing and was designed by the Trussed Concrete Steel Company (Fig. 7). The exterior columns and beams are lined on the outside with brick. The floors and roof are of 6-inch concrete, the roof being designed as a future third floor of the building. It is covered with a cinder fill and composition roofing. The

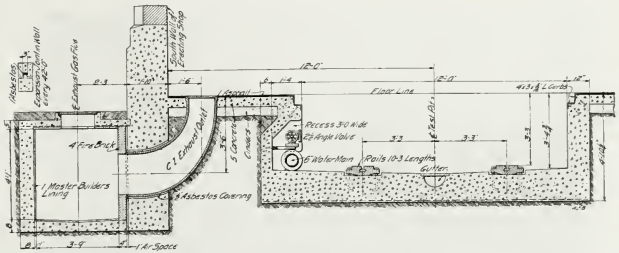


Fig. 5. Cross-Section Through Test Pit and Exhaust Gas Flue.

stairs are of reinforced concrete, the elevator shaft is of brick, and the toilet partitions of tile. The pattern shop is on the first floor and is equipped with a shaving exhaust system. The tools are individually motor-driven. Both floors and the basement are equipped with automatic sprinkling systems.

Office Building.

The office building is 88 feet by 44 feet outside and has three stories and a basement. The basement columns and walls are of concrete, the columns being reinforced. The superstructure is of structural steel and brick walls. The columns and downspouts are encased in fireproofing plaster and the beams are covered with concrete. The floors are constructed of hollow tile with 4-inch spaces of reinforced concrete, the sleepers and ¾-inch maple flooring being laid over the tile and concrete. The roof is of tile, covered with cinder concrete and composition roofing.

The stairs are of steel with composition treads. A fire escape is at the east end of the building and a 1½-ton electric passenger elevator is at the north end. The sash, frames and doors at the fire escape are of sheet metal; all other sash are of wood.

The main entrance to the building is at the west end. On the first floor is the administration department; on the second floor are the engineering and drafting departments, and on the third floor are the directors' room, reading room, dining room, toilets, and blue print room. The building is provided with direct and indirect lighting.

Service Building.

The service building is 66 feet by 44 feet outside, and is two stories high. The one-story entrance at the west end is 24 feet

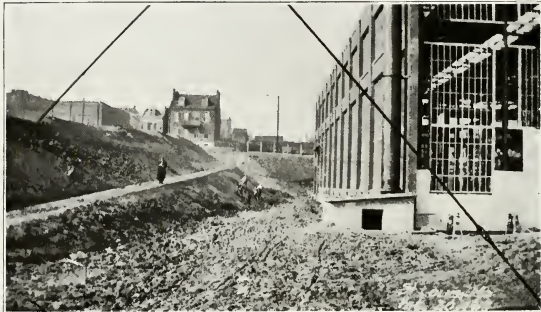


Fig. 6. Southeast Corner of Erecting Shop, Showing Fan House.

8 inches by 11 feet 6 inches, and is divided into a vestibule and gatekeeper's office. The framing is of structural steel. The first floor is of concrete and the second of hollow tile and concrete, as used in the office building, but with a cement finish. The columns, beams and downspouts are encased as in the office building. The roof is of 4-inch hollow tile, covered with cinder concrete and composition roofing. The two stairways at the west and east ends are of channel stringers with concrete treads. All the mill work is of wood.

On the first floor are the lavatories, lockers, toilets, showers and surgery. On the second floor is a lunch room and space for future lockers and lavatories.

Power House.

The power house is 79 feet 4 inches by 66 feet outside the brick work and has a boiler room 63 feet by 35 feet 3 inches wide and an engine room 63 feet by 40 feet wide. A plan and cross-section are shown in Figs. 8 and 9. The frame work is of structural steel, the height to the bottom of the truss being 19 feet in the boiler room and 25 feet in the engine room. Most of the basement is occupied by the engine and compressor foundations. The brick piers shown in the section are temporary and support the floor over the future engine foundations. The floors are of concrete and the cement finish in the engine room is colored red, with a black border around the bases of the machines and around the room adjacent to the walls. The roofs are of cement tile

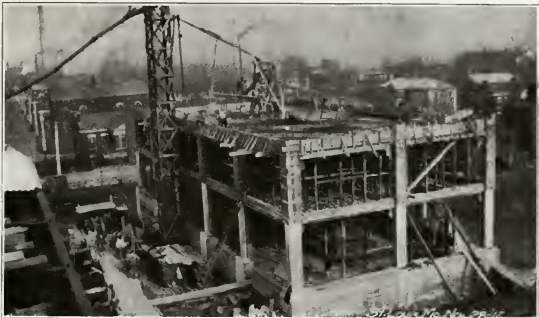


Fig. 7. View Showing Reinforced Concrete Pattern Storage Building Under Construction, Looking Northeast.

covered with composition roofing. The engine room has a 6-foot wainscoting of enameled face tile with a 10-inch concrete base mold. The sash and sliding doors are of steel. The engineer's office is located in the northwest corner of the boiler room, under the steam heater platform. The entrance to the tunnel running between the power house and machine shop is on the west side of the building, as shown in Fig. 8. This tunnel is of concrete, 7 feet high and 8 feet wide inside.

The steam boilers are used for supplying steam to the heating system and to the steam hammers in the forge shop and to some of the auxiliaries, while the Diesel engines are used for furnish-

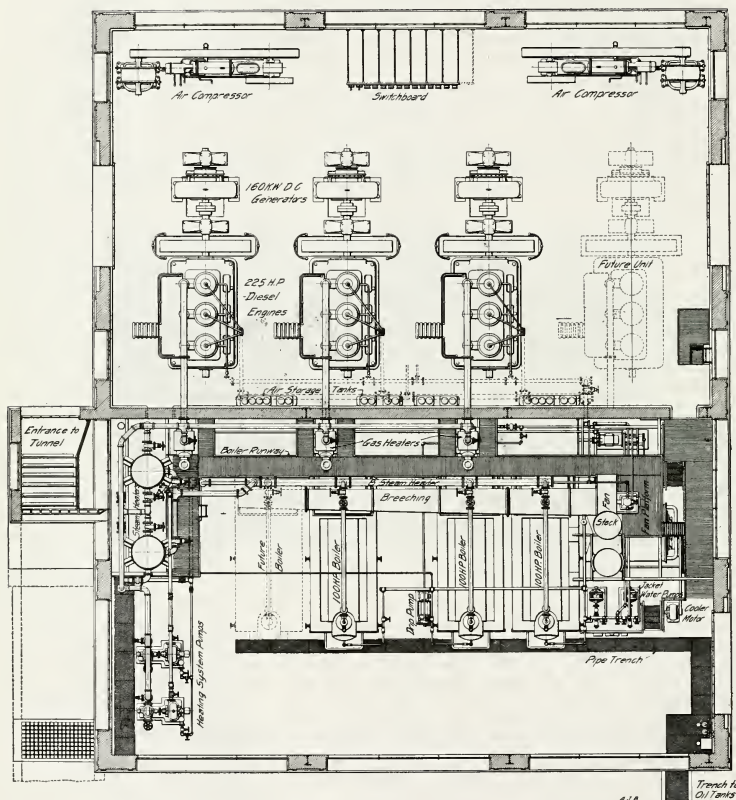


Fig. 8. Plan of Power House.

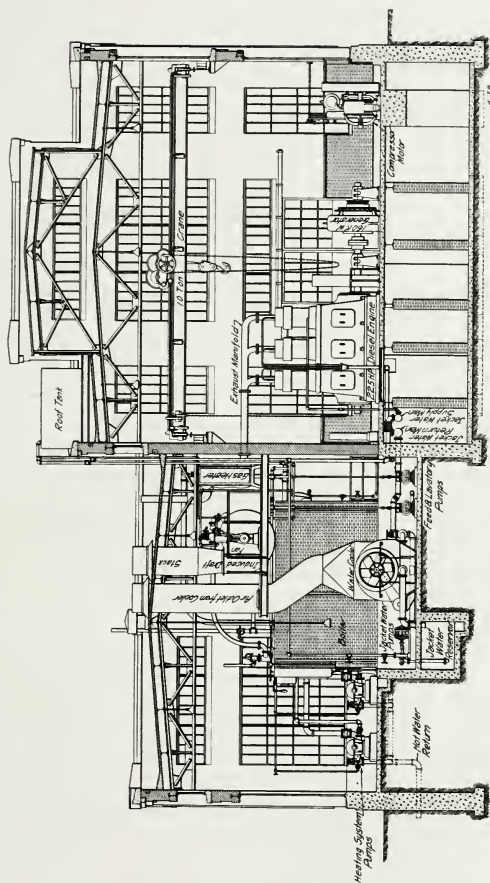


Fig. 9. Sectional Elevation of Power House.

ing light and power. By referring to the plan and cross-section the following description of the power house will be better understood. Steam is furnished by three 100-horsepower oil-burning Heine boilers, using the W. H. Best burners. The oil fuel for the boilers is supplied from two 12,000-gallon tanks 8 feet 6 inches diameter by 29 feet 6 inches long, encased in concrete south of the building, by means of the oil system of the Hydraulic Oil Storage & Engineering Company. The metering apparatus is placed in the southeast corner of the boiler room and another is placed in the engine room. The oil pipes from the meters run in the trench along the front of the boilers. A 3-inch feed line above the boilers supplies the 1½-inch connections at the front ends of the drums. The uptakes connect to a tapering steel breeching, of rectangular cross-section, suspended from the trusses. The eastern end of the breeching is connected to a steam-driven 80-inch steel plate exhaust fan of the B. F. Sturtevant Company, which discharges the flue gases up a 3-foot diameter steel stack. The fan is set upon a steel platform 12 feet 3 inches above the floor. This platform connects with the runway behind the boilers and with the platforms, upon which are placed the steam and gas heaters. The 3-inch blow-off main is run behind the boilers on the floor and to the blow-off sump placed in the ground on the east side of the power house. The 4-inch steam leads connect through an automatic stop and check valve and a gate valve to the 8-inch header, which supplies the two steam heaters.

Between the boilers and the eastern wall is a pit 4 feet deep, in which are placed the feed, lavatory and jacket pumps and the water cooler. The two steam pumps are of Worthington duplex type, 6 inches by 4 inches by 6 inches, both or either of which may be used for feeding the boilers. Normally one is used to supply the hot water for the lavatory service. Both pumps get their supply from the hot well behind the two boilers next to the pit. The lavatories may also be supplied by one of the two motor-driven, 100-gallon Worthington centrifugal pumps. The other centrifugal pump is always used for the jacket water supply. See Fig. 10.

The jacket water pump draws water from the sump directly beneath it and discharges it into a 1500-gallon tank on the roof of the engine room as shown in Fig 9. This tank supplies the

engine and compressor jackets by gravity and the warm water outlets may be run into the hot well or into the sump or passed through the cooler and then into the sump. See Fig. 10. The cooler is made by the Power Specialty Company and consists of a number of horizontal concentric cylinders with narrow intervals. A motor rotates these cylinders and also a fan, which forces a draft of air through the cooler. The water is exposed to the air in thin sheets and thus cooled. When there is a deficiency of water in the sump a low level float valve in the roof tank allows city water to supply the jackets.

The two De Laval steam turbine-driven centrifugal pumps for the heating system are located at the west end of the boiler room. The pumps draw their supply from the 6-inch hot water return main and the water from the 6-inch discharge passes through the gas and steam heaters in series or through either separately. The three gas heaters are of cast iron, made by the Williams Tool Company, and are used for the purpose of extracting from the exhaust gases of the engines a proportion of the heat usually lost. The 8-inch engine exhaust enters at the bottom and leaves at the top, while the water enters at the top and leaves at the bottom, thus giving the counter-current effect. The condensation in the live steam heaters is removed by a Gardner duplex pump, 6 inches by 4 inches by 6 inches, and is discharged into the boiler feed line through a check valve, with a relief valve opening into the hot well. The exhaust steam from the heating system, boiler feed, and drip pump is discharged into the hot well, with a back-pressure valve opening into the atmosphere.

The engine room contains three main units, each consisting of a vertical three-cylinder 225-horsepower 4-stroke cycle Diesel engine directly connected to a 160-kilowatt, 115-230 volt, direct current Crocker Wheeler generator and running at 164 revolutions per minute. Each engine has the following connections: 2-inch jacket water supply, 4-inch warm water return, 1-inch starting air, $\frac{3}{4}$ -inch air for injection and a $\frac{3}{4}$ -inch oil supply from the auxiliary oil tank. The air for starting and injection is stored in vessels, set up along the south wall of the engine room, by two 3-stage Ingersoll-Rand air compressors each driven by a belt from a 50-horsepower direct current Crocker Wheeler motor. The compressor cylinders are 10 inches by $6\frac{1}{2}$ by 3 inches by 12 inches stroke. The switchboard consists of seven panels, each

20 inches wide by 90 inches high. The machinery of the engine room is handled by a 10-ton hand-operated crane, with a span of 38 feet 3 inches, manufactured by the Whiting Foundry Equipment Company.

Drainage and Sewer Systems.

The run-off from the roofs is conducted to downspouts which connect to manholes by means of vitrified sewers. Drainage connections from bell traps to manholes are cast iron soil pipe inside of buildings and vitrified sewer tile outside of buildings. Toilets

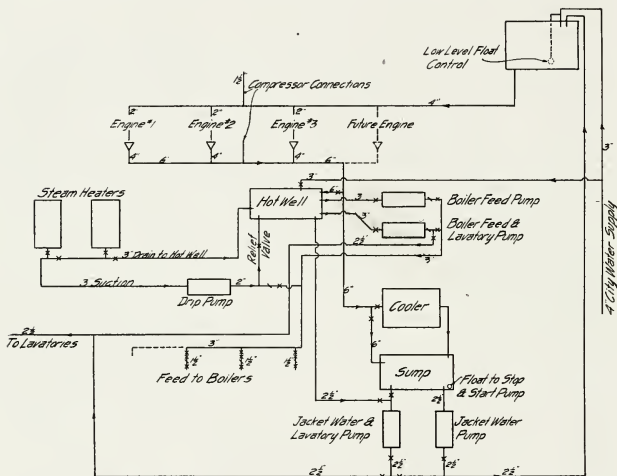


Fig. 10. Diagram of Boiler Feed, Jacket and Lavatory Water Piping in Power House.

and catch basins connect to manholes through vitrified sewers. There are twelve of these manholes at various points on the ground and each has from two to six inlets. They are all constructed with brick walls and concrete bottoms and are 4 feet inside diameter. The 10-inch, 15-inch and 20-inch outlets from three of these manholes connect with two city brick sewers leading to the Mississippi River.

Water System.

A 12-inch city water main in Utah street supplies water through a meter placed in a manhole, to a 6-inch pipe running parallel to

Second street. This 6-inch main divides at a valve manhole at the south end into a 4-inch connection, which extends west and supplies water to the machine and erecting shop for fire and general purposes, and a 6-inch connection which connects, through a meter, to the water main in Cherokee street. In this way water may be supplied from either the north or south ends. From this latter 6-inch connection a 4-inch supply goes to the pump house. The 6-inch yard main from Utah street supplies the eastern end of the machine shop and all the other buildings.

The pump house is 13 feet by 8 feet outside, with 13-inch brick walls and a 2-inch cement tile gable roof. It is erected over a concrete sump of 8-feet inside diameter and 9 feet deep with 12-inch walls. Over the pump house is erected a 30,000-gallon water tank, of the Chicago Bridge and Iron Works, with a head of 142 feet. The purpose of the tower is to obtain a steady pressure on the water brakes used in testing engines. The pump house contains a motor-driven Lewis multi-stage centrifugal pump with a capacity of 200 gallons per minute and head of 170 feet. The pump normally draws water through a 4-inch pipe from the sump, which is supplied by the 8-inch discharge pipe from the test pit in the erecting shop. The overflow from the water tank also flows into the sump. When the water level is too low a float valve opens a by-pass to the 4-inch city connection, allowing the pump to receive city water directly. The pump discharges through a check valve into the 6-inch stand-pipe, one branch rising to the tank and the other dropping below the ground and running to the erecting shop. The water in the sump overflows to the sewer when reaching a head of 4.5 feet. Both the supply and overflow pipes of the tank are covered with a frost casing. The water in the tank is kept from freezing by circulation through a Wainwright heater, 50 feet square, placed in the pump house. The heater receives its heat from a hot water connection of the heating system in the erecting shop.

Heating System.

All the buildings are heated by the Evans Admiral System of Hot Water Heating. The 6-inch supply from the power house divides into a 5-inch line, which runs in the tunnel to the southern group of buildings, and into a 4-inch line which supplies the northern group. The supply and return for the machine and

erecting shops are 5-inch, and the 15,720 square feet of radiation consist of coils of $1\frac{1}{4}$ -inch pipe placed on the side and end walls and also overhead, below the trusses. The $1\frac{1}{2}$ -inch supply and return for the forge shop are carried in the trusses of the raw material storage crane runway and the 800 square feet of radiation consists of pipe coils on the walls. The office building has $2\frac{1}{2}$ -inch supply and return mains and 2,400 square feet of radiation consisting of pipe coils in the basement and radiators on the other floors. The service building has 2-inch supply and return mains and 1,120 square feet of radiation in pipe coils and a few radiators. The pattern storage building has $2\frac{1}{2}$ -inch supply and return mains and 1,980 square feet of radiation in pipe coils. The heating mains for the office, service, and pattern storage buildings, are placed in ducts made of 18-inch split tile arched over a concrete base 5 inches thick. The $1\frac{1}{2}$ -inch heating pipes to the pump house, for the heater, connect with the erecting shop circuits and are placed in a 15-inch split tile duct.

Power and Lighting Systems.

Direct current is used for all power. The tools in the machine and erecting shops, forge shop and pattern shop are operated on 3-wire, 110-220 volt circuits, while all the motors in the power house, the elevator in the office building, and the elevator and cranes in the machine and erecting shop are operated on 2-wire, 220-volt circuits.

Both alternating and direct currents are used for lighting. The yard, tunnel, and watchman's lights are on alternating current, 2-wire, 110 volt circuits. All other lighting circuits are 3-wire, 110-220 volts, direct current being used in the machine and erecting shop, forge shop, and pattern storage building, and alternating current in the power house, while either alternating or direct current may be used in the office and service buildings.

The yard lighting consists of 100-watt tungsten lamps attached to corners and sides of the buildings; the watchman's lights are 40-watt tungsten lamps placed at various points in the buildings; and the tunnel lights are 25-watt tungsten lamps.

The writer is indebted to the Busch-Sulzer Bro. Diesel Engine Company for permission to publish the above article and to Mr. P. L. Battey and Mr. H. G. Treichel of the Arnold Company for having read the manuscript and offering suggestions.

THE MANUFACTURE OF PIGMENTS, AS SEEN BY THE INSURANCE ENGINEER.

BY JOEL R. WILSON.*

The duties of a fire insurance engineer, whether he is in the service of a fire insurance company, a board of fire underwriters or a fire insurance agency, call him into more fields of industry probably than do the duties of any other engineer. Each succeeding day he is called upon to wrestle with the question of fire prevention and fire protection in a different class of industry. He is expected to have a sufficient knowledge of electricity and chemistry to be able to walk into any manufacturing or industrial plant or into the vast warehouses and mercantile houses of the present day and determine the specific fire hazards involved; offer suitable and practical methods for eliminating as many hazards as possible and safeguarding the others, so that the liability of a fire will be reduced to a minimum. He must thoroughly understand the subject of hydraulics so that he may lay out a practical system of fire protection such as water mains, fire hydrants and automatic sprinkler systems. He must have a thorough understanding of building construction and the fire resistive qualities of the various types of construction with the ability to offer suggestions for improvements tending to increase the resistance to the ravages of fire. In other words, he is expected to have at hand a greater range of general technical information than those engaged in almost any other engineering field.

The above mentioned requisites are necessary if an intelligent report is to be made on the fire prevention and the fire protection of any industry. The assured, on seeing a report on his plant, is generally eager to carry out any suggestions that may be made in safeguarding his interests from a disastrous fire, but he is equally obstinate if he is called upon to make any changes which cannot be proven to him as necessary. On the other hand, the engineer's

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employers would be highly dissatisfied with him were a disastrous fire to occur to a risk by reason of some poorly safeguarded hazard, which he had failed to discover and offer proper remedies for.

The above remarks are merely introductory that those not familiar with the duties of the fire insurance engineer may understand why the following article is written. The manufacture of pigments is only one of the many industries visited by him and is merely selected to show how one must be able to differentiate between hazardous and non-hazardous processes.

Dry colors or pigments are either mineral or organic bodies which are usually insoluble in water, oils and other neutral solvents. They are used to impart color to a body either by mechanical adhesion to the surface of that body or by admixture with its substance. In most cases there is no chemical combination between a pigment and the body it colors.

Many of the mineral pigments occur in the earth as natural pigment and the only preparation required is grinding and levigating. Some are prepared by simple precipitation, and the precipitate then dried at a low heat, after which it is pulverized. A great many pigments are obtained only after several intricate chemical reactions combined with roasting, grinding, levigating, etc. Some pigments are mixtures of two or more other colors in proportions required to obtain the desired shade.

White Pigments.

White lead is the principal white pigment, and, chemically speaking, is a mixture of lead carbonate and lead hydrate. This mixture is usually in the proportion of two parts of the carbonate to one part of the hydrate ($2\text{PbCo}_3 \text{ Pb OH})_2$) and is made in various ways. The Dutch process is, however the most universal method and consists in exposing sheet lead to the direct action of moisture, acetic acid vapors and carbon dioxide. Dilute acetic acid is placed in earthenware pots, and irregular or spiral-shaped pieces of sheet lead, which expose considerable surface to the fumes, are placed on shelves in the pots. A large number of these pots are placed side by side upon a layer of spent tan bark. Lead gratings are placed across the top of these pots. About 6 inches above the latter is constructed a plank floor on which a layer of tan bark is placed and on this another set of pots containing acetic acid and lead. In this manner stacks of alternate layers of tan bark and

pots are built almost to the ceiling. A space of about 6 inches, which is left between the stacks and the walls of the building, is filled with tan bark. Very soon after stacking an active fermentation of the tan bark sets up and the temperature rises to about 140° F. The heat evolved causes the acetic acid and water to evaporate, the vapors attacking the metallic lead and forming basic lead acetate. The fermentation of the tan bark liberates great quantities of carbon dioxide, which decomposes the lead acetate and forms basic lead carbonate, or white lead. This process consumes about two months and several quicker methods have been adopted with varying degrees of success.

One of the quicker processes which requires but a few days and which is said to obtain a good uniform white lead, consists of melting pig lead and forcing it, by means of steam, through a small orifice into a very large hopper-shaped container. The force with which it is injected into the hopper practically atomizes the lead, which, before reaching the opposite side of the hopper, has cooled in the atomized form and drops to the bottom of the container in a very fine granular form. The granular lead is then placed in wooden drums and subjected to moisture and to the vapor of acetic acid and carbon dioxide. The drums revolve slowly, making only one revolution every fifteen minutes. A chemical reaction sets up which is identical to the reaction in the old Dutch process.

In both processes, the pasty mass is thoroughly washed to remove all foreign matter and then placed on trays and removed to steam-heated driers. It is then broken up, ground and pulverized.

Barytes or barium sulphate is a white pigment which occurs in large quantities natively and is used as an adulterant very extensively in white lead. The only preparation required is grinding, removing the foreign iron by treatment with hydrochloric acid, and levigating, after which it is dried and pulverized.

Gypsum, which is a hydrated calcium sulphate, occurs natively and is also a by-product in numerous processes. It simply requires grinding, treatment with acid, drying and pulverizing.

Whiting, or Paris white as it is sometimes called, is a carbonate of lime. It is prepared by grinding and levigating pure chalk, which occurs in large quantities in England, France and other European countries. It is used extensively to modify the shades of other pigments by simple admixture with them.

Zinc white, or oxide of zinc, is one of the principal white pigments and for some purposes is superior to white lead. It is used medicinally and is also finding a market in the automobile tire industry. It is made by distilling the metallic zinc in fire clay retorts. The vapors are led into a flue through which air is drawn, burning to zinc oxide which is collected in a series of settling chambers.

Blue Pigments.

There is practically only one blue pigment that occurs natively and that one is ultramarine blue. It occurs, however, in such small quantities as to make it too costly for use as a pigment and hence is replaced by artificial ultramarine. It is considered as a double silicate of sodium and aluminum together with a sulphide of sodium, the latter being the property which gives the beautiful color to the compound.

The description of the process of manufacture of the artificial ultramarine would be too lengthy and it is sufficient to say that it is prepared by fusing in closed crucibles a mixture of china clay, sodium carbonate, carbon and sulphur. This produces a green ultramarine which on reheating becomes blue. It is this ultramarine blue which is used so extensively in wall paper colors and for printers' inks, paints, etc.

Prussian blue is one of the principal blues on the market and chemically is the ferrocyanide of iron. It is made by the action of potassium ferrocyanide on an acidified solution of copperas (sulphate of iron). The precipitate obtained is white ferrous-ferrocyanide, but on treatment with nitric acid the blue is obtained. It is not affected by acids and mixes well with oil and can be dissolved in oxalic acid, giving a blue solution formerly used much for inks.

Turnbulls blue is a deep reddish blue obtained by copperas and potassium ferricyanide instead of ferrocyanide.

Indigo blue is an organic substance used as a pigment in calico printing. However, this comes under the head of natural dye-stuffs such as logwood, cochineal, litmus, madder, cudbear, turmeric, etc. They differ from pigments in that they are all soluble in water. Indigo itself (as extracted from the indigo plant grown in India) is insoluble in water, alcohol, ether, dilute acids and alkalies. It can be made soluble by treatment with fuming sulphuric acid; and the sodium salts of this constitute the soluble

indigo or indigo carmine of commerce. Many of these extracts are not dyes in themselves, but become so when treated with mordants.

Green Pigments.

Chrome greens, true Brunswick greens and ultramarine green (obtained as described under ultramarine blue) and the copper and arsenic greens are the principal greens.

The chrome greens are more extensively used and are obtained by simple precipitation, that is, precipitating a chromate with soda; chromic hydrate is thus obtained. This precipitate is then heated at a red heat (water expelled) giving chromic oxide, the basis.

True Brunswick green is the oxychloride of copper made by subjecting copper for several weeks to a solution of common salt containing sulphates. The insoluble pigment is washed and dried at a low temperature. This, however, is replaced by pigment sold under the name of Brunswick green, which is a mixture of Prussian blue, chrome yellow and barytes. They are sold also under the names Victoria, Prussian or chrome green. These pigments cannot be mixed with other pigments containing sulphur or alkaline substances nor used where exposed to hydrogen sulphide (the alkalies acting on the Prussian blue and sulphur darkening the chrome yellow).

The copper and arsenic greens surpass all the other greens in their brilliancy and beauty, but on account of their poisonous qualities cannot be used extensively. One of the principal greens is Paris or emerald green, with which all are familiar.

Yellow Pigments.

The principal yellow pigments used are the chrome yellows, yellow ochres and siennas. The chrome yellows are chromates of lead, zinc or barium, each having its own peculiar shade and all are made by simple precipitation. For instance, lead chromate is prepared by adding potassium bichromate to a salt of lead such as lead acetate or nitrate. Modified shades are made by mixing and grinding with the different pigments lead sulphate or barytes. The yellow ochres and siennas are natural mineral products, the colors varying from yellow to brown and containing large quantities of sand and clay; their coloring is said to be due to hydrated oxide of iron and some manganese oxide. They occur in beds in the earth and the only preparation necessary is grinding and

levigating. By heating or calcining the water of hydration in the iron oxide is driven off and the resultant colors are darker orange and reds, according to amount of moisture expelled. Burnt sienna, much used for staining birch to a mahogany, is sienna which has had its water of hydration driven off by intense heat. There are other yellows such as litharge, an oxide of lead, which is made by oxidizing metallic lead at a high temperature. This pigment is used extensively as a drier in the preparation of boiled linseed oil. Orpiment, or arsenic tri-sulphide, occurs as a native mineral and is sold under the name of royal yellow or king's yellow. It is not used extensively on account of its poisonous character.

Gamboge is a gum resin obtained from a tree of Siam, emulsifies readily with water and for this reason is used as a water color more than for oil paints.

Red Pigments.

There is also a chrome red as well as a chrome green. Chrome red is made by simply boiling chrome yellow with caustic soda or lime. It is basic lead chromate. This is sold under the names of chrome red and chrome orange, according to whether lime or soda was used. They are also known as American vermilion and Chinese red. Imitation chrome red is made by mixing coal tar eosin with white lead. Also, we have a red ochre. This is prepared by calcining yellow ochre, driving off the water of hydration in the iron. The more water expelled the darker the shade. Oxide of iron has been mentioned several times as the color-giving property in the siennas and ochres. Hence iron oxides themselves are good color pigments. The red oxide of iron is made principally as a by-product in the manufacture of fuming sulphuric acid and it would be worth while to mention this briefly.

Fuming sulphuric acid occurs when copperas (sulphate of iron), a by-product in wire and iron works, is heated strongly in furnaces. The substance decomposes, forming two compounds, namely ferrous sulphate and ferric sulphate. On further heating the compounds break down, throwing off sulphur dioxide and sulphur trioxide, which are collected in receivers containing sulphuric acid. This resultant mixture with sulphuric acid is fuming sulphuric acid, or probably better known as Nordhausen acid. The residue in the retort is red oxide of iron, which after grinding,

washing and drying, becomes a very permanent and valuable pigment especially for iron work. Mercuric sulphide is a very bright red pigment, but is not used extensively on account of its costliness. This is also known as cinnabar.

White lead or other white pigments very often are colored with eosin or other coal tar dyes. These are called vermilionettes.

Carmine belongs to a class of pigments called "lakes," which are metallic salts of organic color acids. For instance the color principal in carmine is carminic acid which is obtained from the bodies of cochineal insects by extraction with hot water and adding a solution of alum or tin-chloride and cream of tartar. After standing, the carmine precipitates. Carmine is a very bright red and is used extensively as a water color and oil paint as well as rouge. I will not attempt to give the browns in detail. It is sufficient to say they are most all indefinite mixtures of iron oxides and organic matter. Some browns are ochres containing a greater amount of manganese than the siennas, while others are mixtures of lampblack, yellow ochre and iron oxide.

Black Pigments.

The principal black is lampblack which consists of the soot from the very smoky flames produced by burning in a deficient supply of air, highly carbonaceous substances like fats, resins, oils, turpentine or tar. The soot is condensed often on cloths hung up in chambers through which the smoke has to pass or on the surfaces of revolving metallic cylinders cooled by water. The burning is conducted at so low a temperature that the hydrogen of the hydro-carbons is consumed, leaving the carbon. This form of carbon is very likely to have traces of oil mixed with it which failed to pass out of the chamber and it is to this oil that the the danger of spontaneous combustion is responsible.

Carbon black is produced in natural gas regions chiefly, through the imperfect combustion of the gas under artificially cooled, revolving metal plates. The soot is scraped off of these plates into paper bags the same as lampblack. Carbon black is much rougher than lampblack and contains no unburnt oil as does the latter. It is very important in inspection work to know whether lampblack or carbon black is used, the latter being less hazardous.

Ivory black is obtained by heating refuse ivory. When ground it makes a very fine grade of pigment. Bone black is from bones

charred in retorts. It is inferior for pigment, but is used extensively in the sugar industry and for leather blacking.

Charcoal and graphite all are familiar with. The latter makes a fine pigment for outside iron work. It is also used for crucibles and electric carbons.

Black lakes (from a mixture of logwood decoction, copperas and bichromate) are not permanent.

Tannate of iron formed by mixing tannin liquors with copperas do not make durable pigments, being affected by light.

We have now covered all the principal pigments and it might be well to turn to the hazards of these substances in general.

The white lead works is an industry in itself and the manufacturers of white lead do not as a rule enter into the manufacture of any other pigments. This is also true of the zinc white industry. Both require a great deal of space.

The drying feature is common to all color works. The driers are usually heated by steam and of fireproof construction. The pasty mass is laid on wooden trays and placed on racks in the driers. It is up to the engineer to determine in each case whether the driers are safely installed from the point of fire hazards.

In the zinc white industry fire clay and brick retorts are used in which the zinc ore is roasted. Floors and surroundings should be of non-combustible construction and the flues should be safely arranged; especially is this true where any parts of the building itself are of combustible construction and subjected to the intense heat from the flues and furnaces. The hot zinc oxide is generally collected in large cloth sacks hung in vertical rows. These sacks become so hot that they occasionally ignite and it is necessary that they be closely watched; also extinguishing apparatus should always be at hand.

All dry colors must be ground before they are suitable as a pigment and therefore grinders and crushers are found in all dry color works. The substance is first run through a crusher (sometimes called a pulverizer) which consists of a series of blades arranged on the circumference of a revolving shaft, the whole inclosed in an iron box. The blades reduce the pigment to small lumps which are conveyed to the grinders arranged in batteries; the substance passes through one grinder, is elevated and dropped into the next one and so on until it has gone through

each one, becoming finer in each succeeding grinder. The surroundings become extremely dusty. Fine powder of all colors drops onto everything in the room.

We all know that a combustible solid or a liquid may under certain conditions act like a gas; if it be finely divided and suspended as a dust in an atmosphere containing a gas with which it can ignite the mixture resembles very closely a mixture of two gases which given an opportunity will combine with explosive effect.

The chances of a dust explosion in a dry color mill depend on the substances which are being ground and mixed. Some dry color mills confine themselves to such substances as barytes, the siennas, and various other non-combustible colors. Some mills do not confine themselves but make any and all colors and grind them all in the same room. A dry color mill grinding and pulverizing the chromes, the Prussian blue, carbon and vegetable blacks which are oxidizable would have to be treated differently, as these substances are quite inflammable when distributed in finely divided particles.

The chance for an explosion is especially magnified when many dry colors, such as red lead, yellow lead or litharge, manganese dioxide and lead chromate, which are powerful oxidizers, are ground and mixed with oxidizable pigments. An example is the mixing of Prussian blue with lead chromate in the preparation of a chrome green.

To minimize the hazards mentioned, all grinders and mixers should be equipped with magnets in the feed devices, so that no metallic substances can in any manner find their way into the machines. A nail or any other foreign piece of metal would cause a spark which would ignite the dusty atmosphere. All machines should be connected to an approved cyclone dust collecting system to eliminate dust in the room as far as possible. No open lights should be tolerated and electric lights should be in approved vapor tight globes. As a further precaution, the grinding of combustible colors should be confined in a separate building.

The storage of certain dry colors presents a serious fire hazard. None of the pigments, with the exception of lampblack, have been known to ignite spontaneously. Pure greens and blues will burn and are easily ignited with a spark when in the dry powder form, but this property disappears when the color is mixed with oil.

The darker greens ignite more readily than the light greens due to the greater percentage of ferrocyanide.

A case is on record where a cask of red color made from eosin and red lead took fire. The cause was traced to a lighted gas jet which ignited the fine dust raised on opening the cask. The fire spread to the bulk in the cask and the combustion was there maintained at the expense of the oxygen contained in the red lead.

A fire was prevented in a retail paint store by the timely discovery of a burning drawer of Prussian blue. The proprietor saw smoke issuing from this drawer, and after opening it discovered it to be burning. The flames were extinguished before serious damage was incurred. The proprietor claimed that he used the drawer for storage of pigment only. It was assumed that this was a case of spontaneous combustion and accordingly an examination of the substance and a test for spontaneous combustion was made. The substance proved to be fairly pure Prussian blue and did not show any tendency toward self-heating. Therefore spontaneous combustion was out of the question. Prussian blue burns with an intense blue flame giving off ammonia fumes.

The conclusion drawn from the above mentioned test was that the fire was caused either by accidental spilling of linseed oil into the drawer, ignition of matches by rats or by workmen leaving traces of linseed oil from their hands when taking a supply from the drawer.

A 100,000-GALLON REINFORCED CONCRETE TANK.

BY TIRRELL J. FERRENZ, JUN. W. S. E.*

The Chicago City Railway Company has recently installed at its Seventy-seventh Street Plant a high pressure fire protection system, the most salient feature of which is a 100,000-gallon reinforced concrete tank. This tank is elevated upon a concrete tower 70 feet in height, and is designed to supplement a 6-inch three-stage Jeansville centrifugal pump of 1,000 gallons per minute capacity. The pump, which draws water from a 12-inch city main, is direct connected to a 100-horsepower direct current motor and runs at 1100 revolutions per minute. Water is pumped into the tank through two 6-inch risers which are imbedded in two of the legs of the tower.

The various shops, offices and storerooms comprising the company's plant are one and two stories in height, and are of a compromise mill and fireproof construction, some of the older structures having wooden roofs. These buildings have been equipped with several thousand automatic sprinklers, which are divided into twenty-one independent sections, each being controlled by a separate indicator post gate-valve. Numerous fire alarm boxes, with bell and annunciator in the main engine room, complete the system. The opening of a sprinkler, or the withdrawal of water from a hydrant, automatically starts the fire pump, and when the normal pressure of 90 pounds per square inch maintained by the pump is reduced to 45 pounds, the water from the tank will feed into the system. It is estimated that the tank will supply four 1¼-inch nozzles for four hours.

Tank.

The tank is designed to carry safely 116,000 gallons, but its capacity is limited to 100,000 gallons by a 2-inch over-flow pipe which is encased in one of the columns. To prevent freezing in

*Class of 1911. Structural Designer, Chicago City Railway Company.

exceptionally cold weather, a steam coil of $1\frac{1}{4}$ -inch pipe is placed inside the tank near the bottom, the supply and return pipes paralleling the two 6-inch risers.



Fig. 1. View of Completed Tank.

The bottom of the tank is composed of a truncated cone and a spherical invert. The sizes of these are so proportioned that the horizontal trusts over the supporting circular girder are approximately equal and opposite; as shown in Fig. 4. The outward

thrust of the frustum is taken care of by a properly enlarged and reinforced concrete section at the base of the shell, a similar section being used to care for the outward thrust of the roof dome. It will be noted that the shell of the tank is 8 inches thick, although only 4 inches thick is called for by the computations; the designer states that 6 inches would be used if another tank were built, as greater thickness weakens the structure by the additional load.

The tank was waterproofed inside by three coats of cement finish, each being about $\frac{1}{8}$ -inch thick. The proportions used were 1 part cement, 1/10 part hydrated lime, and 1 part sand. The

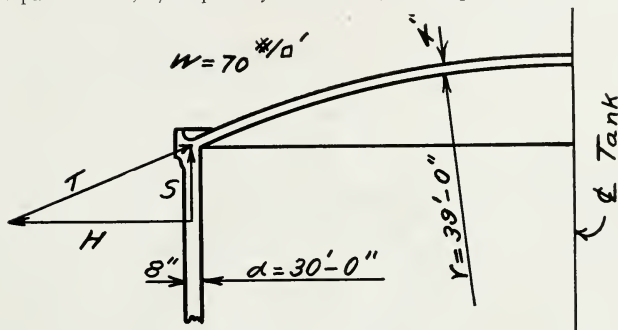


Fig. 2. Forces Acting on Roof.

methods used in designing the various parts of the structure follow:

Roof.

The roof is a section of a sphere 39 feet in radius and 3 feet high, its weight being $2\pi rh \times 70 = 58,000$ pounds approx. The vertical reaction or shear per lineal foot of circumference at the base of the dome is

$$S = \frac{w\pi d^2}{4} \div \pi d = \frac{wd}{4}$$

As shown in Fig. 2, this shear may be divided into two components, the horizontal tension H and the thrust T , whose values are graphically found to be $2.4S$ and $2.6S$, respectively; or since $d = 30$ feet, $S = 525$ pounds, $H = 1,260$ pounds, and $T = 1,365$ pounds. These values give a shearing stress at the base of the

dome of $525/4 \times 12 = 10.9$ pounds per square inch, and a compressive stress of $1365/4 \times 12 = 28.4$ pounds per square inch.

The outward thrust H produces a ring action at the base of the dome, as shown in Fig. 3, the resulting tensile strain on the reinforcing being $H \times d/2 = 18,900$ pounds. Assuming four $5/8$ -inch square rods, area 1.562 square inches, the unit stress is $18,900/1.562 = 12,100$ pounds.

Cylindrical Shell.

The shell is 20 feet in height and its thickness is assumed as 8 inches. This gives a weight of $(31.33^2 - 30^2)\pi/4 \times 20 \times 144 = 186,000$ pounds approx. The stress per square inch $= 62.5$ $hd/2t \times 12 = 2.6hd/t$.

The stress in concrete at the base, neglecting reinforcement, equals $2.6 \times 20 \times 30/8 = 195$ pounds per square inch. The

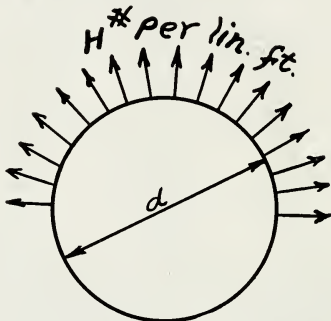


Fig. 3. Forces Acting on Cylindrical Shell.

stress in steel at the base, neglecting concrete, equals $62.5 \times 20 \times 30/2 \times 1.367 = 13,800$ pounds where 1.367 is the area per foot of four $5/8$ -inch square rods spaced $3\frac{1}{2}$ inches apart. The stress in steel at 10 feet above the base equals $62.5 \times 10 \times 30/2 \times 0.781 = 12,000$ pounds, two $5/8$ -inch square rods spaced 6 inches giving an area of 0.781 square inch.

Ring at Base of Shell.

The vertical load on ring at base of shell $= 186,000 + 58,000 = 244,000$ pounds. The load per lineal foot $= 244,000/30.67\pi = 2,530$ pounds. As shown in Fig 4, this force may be divided into two components, a horizontal tension on the ring and a thrust on the conical bottom. Since the angle is 45 degrees, the tension per

lineal foot = 2,530 pounds, and the thrust per lineal foot = $2,530\sqrt{2} = 3,580$ pounds. Assuming two $\frac{3}{4}$ -inch square rods and two $\frac{7}{8}$ -inch square rods, total area 2.656 square inches, the stress on the ring reinforcement is

$$2530 \times \frac{30.67}{2} \div 2.656 = 14,600 \text{ pounds.}$$

Conical Bottom..

The weight of this section is calculated by Guldin's rule and is $6 \times 0.666 \times 27\pi \times 144 = 50,000$ pounds (including ring).
Weight of water on the conical bottom $= (30^2 - 23^2)\pi/4 \times$

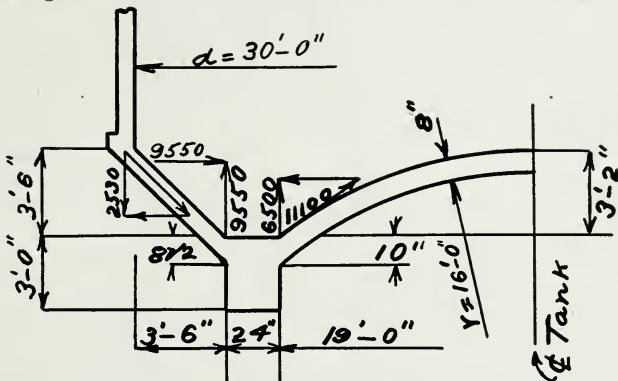


Fig. 4. Forces Acting on Bottom of Tank.

$21.75 \times 62.5 = 396,000$ pounds. Total shear at base of section equals weight of roof, cylindrical shell, conical bottom and water on same, which is 690,000 pounds, or a shear of $690,000/23\pi = 9,550$ pounds per lineal foot. As shown in Fig. 4, this shear may be resolved into two components, a horizontal tension on the ring girder and a thrust on the cone. Since the angle is 45 degrees, the thrust on the cone is $9550\sqrt{2} = 13,500$ pounds per lineal foot, which gives a unit compressive stress of $13,500/12 \times 8 = 140$ pounds. The shear per square inch is $9,550/12 \times 8\sqrt{2} = 70$ pounds.

Spherical Invert.

The spherical invert is a section of a sphere of 16-foot radius. It is 8 inches thick and has a rise of 3 feet 2 inches. Its weight

is approximately $2\pi rh \times 0.666 \times 144 = 32,000$ pounds, and the weight of the water above it $19^2 \times \pi/4 \times 20 \times 62.5 = 355,000$ pounds. The vertical shear or reaction is therefore $387,000/19\pi = 6,500$ pounds per lineal foot. As shown in Fig. 4, this shear may be resolved into two components, a thrust of 11,100 pounds per lineal foot on the invert and a thrust on the ring girder of 9,000 pounds, which nearly counterbalances the thrust from the conical section. The shearing stress is $6500/12 \times 10 = 54$ pounds per square inch; and the compressive stress $11,100/12 \times 8 = 116$ pounds per square inch.

Circular Girder.

The circular girder, which transmits all loads to the columns, is 2 feet by 3 feet in section and weights $2 \times 3 \times 21\pi \times 144 = 57,000$ pounds. This gives a total weight of concrete of 383,000 pounds. Adding 833,000 pounds, the weight of 100,000 gallons of water, makes a total load on the girder of 1,216,000 pounds. Assuming 140,000 pounds carried directly by the columns, there remains a load on the girder of 1,076,000 pounds, or 269,000 pounds on each of the four sections. Since the section at the columns is 4 feet deep, the shearing stress $= 269,000 \times 0.5 \div 24 \times 48 = 116$ pounds per square inch.

Figuring the girder as a continuous beam with supports $13\frac{1}{2}$ feet apart, gives a bending moment of $269,000 \times 13.5/12 = 302,000$ foot-pounds. As this girder is large, the torsional moment must be taken into account, namely, $269,000/2 \times 3/2 = 201,800$ pounds. Considering continuous action, however, the torsional moment at the center may be taken as one-third of 201,800, or 67,300 foot-pounds, and at the supports as two-thirds of 201,800, or 134,500 foot-pounds. The bending and torsional moments are next combined by means of the formula $M = 0.35 M_b + 0.65 \sqrt{M_b^2 + 3 M_t^2}$, resulting in a moment of 170,000 foot-pounds at the center, and 350,000 foot-pounds at the supports.

There are twelve 1-inch square bars at the top of the girder over the supports, and assuming ten of these as effective, the stress in the steel is $350,000/3.5 \times 0.87 \times 10 = 11,500$ pounds per square inch, 3.5 being the effective depth of girder. Similarly the stress in the steel at the center is 9,700 pounds per square inch.

Tower.

In order to economize in ground space the tower was set over an existing building, making it necessary to spread the legs out of

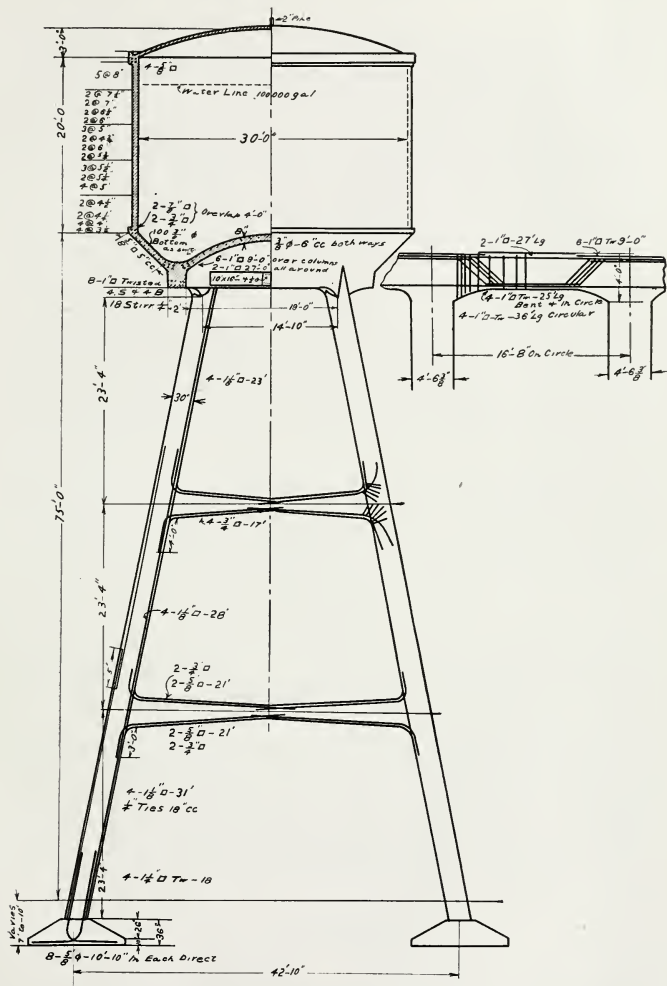


Fig. 5. Cross-Section of Tank.

the vertical and omit the customary diagonal bracing. Through this omission bending moments appear in the columns and horizontal struts, which are greatest at the joints and practically zero at the center of the struts.

Assuming the wind force to be two-thirds of 50 pounds per square foot on the projection of a round surface, the total wind force on the tank is $31.33 \times 27 \times 50 \times 2/3 = 28,200$ pounds. Assuming this force divided between two bents, the direct compression at the base of the column due to wind is $14,100 \times 84 \text{ feet} \div 42.83 \text{ feet} = 28,000$ pounds. The weight of columns and struts is 340,000 pounds, thus giving a total load on each column of $1,556,000/4 + 28,000 = 417,000$ pounds. The resulting compression at base of column $= 417,000/30 \times 30 = 463$ pounds per square inch. Wind load bending moments due to the absence of diagonal bracing increase this stress to 853 pounds per square inch. Since the concrete was proportioned 1:1:2, this stress is not excessive.

It will be noted that the tops of the columns are connected by cross beams. These were inserted to take care of the inward thrusts produced on the circular girder by the weight of the green concrete in the inclined columns. Stresses in the circular girder after completion are held to be vertical only.

Footings.

The footings were proportional for a bearing stress of 2.9 tons per square foot. They were carried down to solid blue clay, and levels taken on the legs before and after filling the tank failed to detect any settlement.

The tank was designed and erected by L. J. Mensch, of Chicago, the construction being carried on under the supervision of Mr. Hugo Schmidt, Superintendent of Buildings for the Chicago City Railway Company. The contract price of the tank was \$6,200. It was estimated that the excess cost over that of a steel tank would be saved in three years' time by the elimination of maintenance expenses.

Specifications.

General Description of Work.—The work to be done under these specifications consists in furnishing all material, tools, appliances and labor, and constructing complete, ready for use, a reinforced concrete tank and tower, exclusive of the sprinkler

pipes, at the Seventy-eighth Street Plant of the Chicago City Railway Company.

Excavation.—Earth, clay or whatever material may be encountered shall be excavated to the hard clay, or at least 5 feet below the surface, and any shoring up of the dry-kiln building adjoining these foundations shall be carefully done by this contractor.

Cement.—All cement used throughout this work shall be first-class Portland cement, which shall comply in all respects to the Standard Specifications for Portland cement of the American Society of Testing Materials, which were adopted November 14, 1904, and all subsequent amendments.

Concrete.—For footings concrete shall be proportioned as follows: 1 sack of Portland cement, 2 cubic feet of sand and 4 cubic feet of crushed stone or gravel. For columns and all other portions of structure: 1 sack of Portland cement, 1 cubic foot of sand and 2 cubic feet of crushed stone or gravel.

The sand shall be clean, well graded torpedo sand, passing a $\frac{1}{4}$ -inch screen.

The crushed stone or gravel shall consist of good hard stone, varying in size from $\frac{1}{4}$ to 1 inch.

The materials shall be mixed in a uniform manner, in wheelbarrows or otherwise, so that the quantities can be easily determined by the workmen and the superintendent.

The mixing shall be done in a batch mixer. When hand mixing is to be resorted to, it shall be done on a tight platform and the materials shall be turned over at least four times until they are homogeneous in color and consistency.

The concrete shall be mixed wet enough to flow freely around the reinforcement and to fill out all the corners in the forms. No concrete shall be used which has partially set. No concreting of columns, girders or walls shall be commenced before they are inspected by the superintendent for cleanliness and proper location of the reinforcement. When starting up concreting after a suspension of only one day, the joints shall be thoroughly cleaned, drenched with water and covered with grout. For a longer suspension, remove from the joint $\frac{1}{4}$ inch to 2 inches of concrete before wetting and grouting.

At least one man shall continually **tamp** a column during process of concreting, and as many more as may be required for all girders and walls.

The inside of the tank shall receive as soon as practicable after the tank is concreted three coats of cement finish, each about $\frac{1}{8}$ to $\frac{1}{4}$ inch thick, and the concrete surface of the tank must be previously roughed with picks to assure a good adhesion of the plaster coat. The cement finish shall be mixed in the proportion of one part cement, $\frac{1}{10}$ part hydrated lime and one part of sand.

Freezing Weather.—When the temperature is below freezing and above 20 degrees F., the concreting may be carried on by using hot water and hot sand and gravel and by protecting the forms and the concrete from the cold by tarpaulins, under which steam circulates. The contractor shall have the right to connect a steam pipe to the company's steam line and may also take hot air from the dry-kiln through a 12-inch by 12-inch conduit.

Reinforcement.—The reinforcements shall be high carbon steel of an ultimate strength of 90,000 pounds per square inch and a yield point of at least 50,000 pounds. The bars shall bend cold around a radius equal three times its diameter to an angle of 90 degrees without breaking. Care shall be taken that all bars are bent as shown in drawings and provisions must be made to maintain the proper position of the rods in the forms during concreting.

Form Work.—The form work must be carefully designed for strength and deflection. The forms shall be built fairly tight to prevent a gross leakage of mortar. The leakage of water colored by cement shall not be considered injurious. The forms shall be erected as true as practicable. The boards for columns and girders shall be surfaced one side and two edges, and the tank forms shall be made of matched boards.

The wooden tower which carries the form work of the tank must be carefully designed, and the weight of the tank and tower must be distributed over the dry-kiln building to prevent an unequal settlement of the building.

The contractor guarantees that the tank will be water-tight and that it will comply with the rules and requirements of Associated Factory Mutual Fire Insurance Companies of New England.

The contractor guarantees to make good, without delay or expense to the railway company, any defects which may develop within one year after acceptance, due to improper materials, design or workmanship.

THE STRUCTURE AND MOLECULAR WEIGHT OF CAOUTCHOUC.

BY FRANK E. BARROWS.*

In an earlier article in *The Armour Engineer*¹ a review of the literature relating to synthetic caoutchouc, and of the theories proposed by Harries and by Pickles for the molecular structure of caoutchouc, has been given, and a modification of these theories suggested.

According to the theory proposed by Harries the hydrocarbons of the erythrene or 1,3-butadiene series, from which synthetic caoutchouc is obtained, first unite to form the 8-carbon cyclooctadiene ring and this ring is polymerized to give caoutchouc. According to the theory proposed by Pickles as an alternative to that of Harries, the hydrocarbons polymerize to form long chains joined together at their ends to form rings containing about 40 carbon atoms.

The modified theory suggested in the article referred to was based upon the assumption that in any so-called straight chain of considerable length and containing unsaturated bonds at regularly recurring intervals there would be a tendency toward ring formation, this tendency being a periodic function of the chain length. It was suggested that such a tendency would result in the formation of a spiral chain with contiguous double bonds joined to and satisfied by each other, so that the final molecule would contain free or relatively free bonds only at its ends; and

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¹ "Synthetic Caoutchouc, a Review Complied from the Literature." by Frank E. Barrows. *The Armour Engineer*, Vol. 3, No. 2, May, 1911; *The Chemical Engineer*, Vol. XIV, No. 3, pp. 355-362, Sept., 1911; *The India-Rubber Journal*, Vol. XLI, pp. 1315-1319 and 1353-1354, June, 1911; and *Gummi-Zeitung*, 25, pp. 1643-1646 and 1688-1690.

that by the saturation of these end bonds with sulfur vulcanisation would be effected.

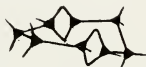
This spiral chain theory, however, is not entirely satisfactory, since the ends of the spiral chain would have to be joined to each other or else free single bonds would remain unsatisfied at each end of the spiral chain. The reaction resulting in the formation of such a spiral chain, or of a straight chain, from the simpler erythrene hydrocarbons would involve the reaction of one bond at a time of each molecule of the hydrocarbon instead of two as in the formation of the cyclooctadiene ring or the formation of the 6-carbon-ring terpenes (dimers). The reactions of the unsaturated hydrocarbons of the erythrene series, however, indicate that reaction takes place either in the 1-2-, or in the 1-4-positions simultaneously. The ozonide reactions of caoutchouc and of the synthetic caoutchoucs confirm the theory that it is by the reaction of these hydrocarbons in 1-4-position with each other to form the cyclooctadiene ring that the first stage of the formation of the synthetic caoutchouc takes place, since these ozonide reactions indicate that caoutchouc itself is closely related to the 8-carbon ring. The presence of such an 8-carbon ring in caoutchouc is further confirmed by the recent experiments of Harries (*Annalen*, 1913, 395, 211-264; *Jour. Chem. Soc.*, 1913, Ab. i., p. 286), which indicate that the ozonides of normal erythrene caoutchouc and of Wilstatter's 1-5-cyclooctadiene have the same reactions and the same rate of decomposition.

The straight chain theory appears to have been based in part, as was also the suggested spiral-chain modification, upon the statement by Berthelot that caoutchouc, upon hydrogenation with hydriodic acid at high temperatures, gives hydrocarbons of the paraffine or straight chain series. The experiments of Berthelot (*Bull. soc. chim.* 1869, nouv. sér., t. XI, 4-35, and 98-99), however, indicate that while a total reduction of the caoutchouc appears to take place, and, while saturated hydrocarbons corresponding somewhat closely to the formula of paraffine hydrocarbons were obtained, yet these hydrocarbons were in some respects materially different from the paraffine hydrocarbons themselves. The reduction was carried out with 80 parts of hydriodic acid at 280 degrees. The ratio of carbon to hydrogen in the product of reduction was not obtained by direct analysis,

but by a rather roundabout way, and would be consistent with a saturated hydrocarbon of high molecular weight belonging to other than the paraffine series. The product of reduction was a viscous liquid which did not crystallize, and which did not volatilize below 360 degrees, although above this temperature it appeared to distill without decomposition. The hydrocarbon behaved with respect to bromine, fuming nitric acid, and fuming sulfuric acid, the same as do saturated hydrocarbons. In order to study further the relation of this reduction product to paraffine Berthelot subjected both the reduction product first obtained and a sample of Pennsylvania paraffine to hydriodic acid at 275 degrees for 20 hours, but in neither case was there any appreciable change. Since the reduction product did not crystallize, but remained a liquid, Berthelot finally concluded that it belonged to a different series from that of the petroleum hydrocarbons. If caoutchouc were closely related to the paraffine or straight chain hydrocarbons it might be expected that upon reduction straight chain hydrocarbons of the paraffine series would be obtained. The fact that they are not obtained indicates that the straight chain theory, as well as any modification of this theory, is untenable. It seems probable, however, that a more careful study of the products of the hydrogenation of caoutchouc would throw further light upon its structure, and it is rather surprising that more work has not been done along this line. If caoutchouc is made up of a series of 8-carbon rings, as is indicated by the ozonide reactions, it is to be expected that the products of complete hydrogenation would be more or less similarly constituted and would also yield decomposition products more or less closely related. Also, if the process of polymerization of hydrocarbons such as isoprene takes place gradually, the hydrogenation of the polymerization product at various intermediate points during the reaction should give saturated hydrocarbons corresponding to these intermediate stages of the polymerization. A progressive increase in the molecular weight of the reduction products would indicate a similar progressive increase in the molecular weight of the caoutchouc.

When an attempt was made by the present writer to construct the cyclooctadiene ring by means of models representing tetravalent carbon it was found that this ring could not be formed with-

out considerable distortion. The occurrence of such a distortion of the ring, with accompanying strain according to von Baeyer's strain theory, was to be expected, as in the case of any ring containing more than 6 or less than 5 carbon atoms. A photograph of the cyclooctadiene ring as constructed is here shown. The models used were regular tetrahedrons with the bonds at the apexes. Free bonds are shown where the hydrogen or methyl groups would be attached. The distortion of the ring is clearly apparent.



(These tetrahedron models were constructed several years ago by Dr. Edwin A. Hill, Assistant Professor of Chemistry at George Washington University, for use in his classes in stereochemistry, but have not heretofore been reproduced in print.)

An interesting discovery with respect to this ring was made on attempting to superpose two of these rings upon each other. It was found that the double bonds of the two rings, when superposed, could be joined to each other to form crossed bonds, as shown in the accompanying photograph, without any additional strain whatsoever so far as the separate rings themselves were concerned.



The distortion of the rings themselves, of course, remains, but these tend to conform generally in configuration to each other when the double bonds are in the position shown. The union of the double bonds with each other in the manner illustrated is somewhat analogous to the union supposed to exist between the double bonds of the benzene ring, according to the centric theory.

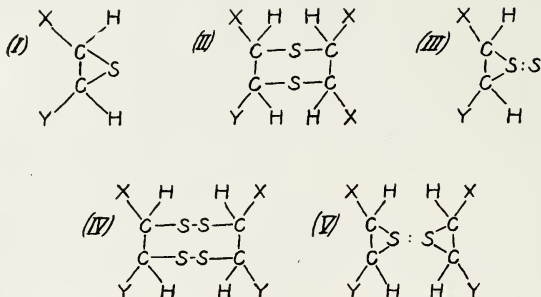
This union of the cyclooctadiene rings suggests an interesting explanation of their polymerization, since it would be theoretically possible to combine almost any number of rings progressively in the same way, while the double bonds of the end rings would still be free to react, either to effect further polymerization or to be saturated by sulfur in the case of vulcanization. The saturation of the terminal double bonds with sulfur or other vulcanizing agent would preclude the possibility of further polymerization. Photographs of the structures illustrated above were shown at the December, 1911, meeting of the Rubber Section of the American Chemical Society in Washington, with a brief reference to the foregoing theory, but no publication thereof has heretofore been made.

Assuming that vulcanization is thus a process of saturation of the end double bonds of the rubber molecule with sulfur, the question naturally arises as to the size and weight of the rubber molecule as indicated by such a reaction. It is known that this molecular weight can be expressed by the formula $(C_{10}H_{16})_n$, so that the molecular weight of vulcanized caoutchouc would be expressed by the formula $(C_{10}H_{16})_n S$. Weber (*The Chemistry of India-Rubber*, 1903 Ed., pp. 91-93) found the minimum amount of sulfur necessary for vulcanization in the case of soft rubber goods to be from 2 to 2.5 per cent and assumed the empirical formula $C_{100}H_{160}S$, or $(C_{10}H_{16})_{10}S$, as representing the lowest member of the possible rubber-sulfur compounds, called poly-prene-sulfides. This formula requires 2.35 per cent of sulfur. Bary (*Comptes rendus*, 1912, Vol. 154, pp. 1159-1160; *Chem. Ab.*, 1912, p. 2183) found that 2.5 per cent of sulfur was the minimum amount necessary to convert soluble caoutchouc into an insoluble sulfur compound. This amount corresponds to the formula $(C_{10}H_{16})_{18.4}S_2$.

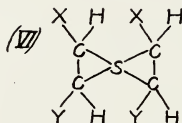
Weber considers (op. cit., p. 56) that true vulcanization consists, not only in the formation of an addition product, but also in the conjugation of india-rubber molecules by means of sulfur.

As to the manner in which the sulfur is attached to the double

bonds of the rubber molecules, as Weber states, all is surmise, but the following possibilities exist (Weber, *op. cit.*, p. 92) :—



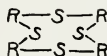
to which it would seem the following might be added, based upon tetravalent sulfur :—



Assuming two free double bonds at each end of the rubber molecule, as would be required by the theory just proposed, then the number of atoms of sulfur necessary for effecting saturation or vulcanization would depend upon whether the sulfur is divalent or tetravalent. If divalent, then the possibilities are those represented by Diagrams I, II and IV, above; if tetravalent, by V and VI; while according to Diagram III, one atom of sulfur would be loosely combined. In the case of divalent sulfur, according to Diagrams I and II, and in the case of tetravalent sulfur, according to Diagram V, four atoms of sulfur would be required for each molecule, by the foregoing theory. In the case of divalent sulfur, according to Diagram IV, and according to Diagram III, eight atoms of sulfur would be required. According to Diagram VI only two atoms of sulfur would be required, sulfur in this case being tetravalent.

The action of sulfur upon caoutchouc is somewhat analogous to its action upon unsaturated fats and oils in the formation of

rubber substitutes (*factis*). Altschul (*Zeit. angew. Chem.*, 1895, p. 535) describes the reaction of sulfur upon various oils, including oleic acid. This acid, when heated with 10 per cent of sulfur at 130-150 degrees, combined with sulfur without evolution of hydrogen sulfide to form an addition product of the formula $C_{18}H_{34}O_2S$ (theory requires 11.35 per cent S; found 11.2 per cent). This experiment would indicate that sulfur, at least in its reaction with oleic acid, is divalent; but it seems questionable whether the analogy between the reaction of sulfur with such an unsaturated acid and with caoutchouc is complete. Altschul suggests the following possible methods of combination of the sulfur:—



where R is a divalent unsaturated fatty molecule. It is interesting to note that the second and third of these suggestions indicate a conjugation of different molecules through sulfur rather than a simple addition of divalent sulfur at each double bond. The stereochemical configuration of the double bonds shown in the models of the cyclooctadiene rings, illustrated above, is such as would enable tetravalent sulfur to join the double bonds of adjacent molecules with very little resulting strain, irrespective of whether the four bonds of the tetravalent sulfur were exerted in the same plane at angles of 90 degrees to each other, or in the direction of the vertices of a tetrahedron. For this reason arrangements of the sulfur with respect to the double bonds such as indicated by Diagrams V and VI seem probable. There seems no way of determining at present in which of these possible forms the union of sulfur with caoutchouc actually takes place, or of determining whether the sulfur is divalent or tetravalent, but it nevertheless becomes possible to speculate intelligently as to the molecular weight of the caoutchouc.*

Assuming, for present purposes, that the formula $(C_{10}H_{16})_{10}S$ given by Weber represents the lowest sulfide containing all the

*The writer is aware that, according to the adsorption theory of vulcanization, no actual chemical combination of the sulfur and caoutchouc is considered to take place; but in the present article the vulcanization reaction is considered to be one of chemical combination between the sulfur and the caoutchouc.

caoutchouc saturated with sulfur, then the relative sizes of the caoutchouc molecules indicated by the possible modes of combination of the caoutchouc and sulfur according to the foregoing theory, which assumes two free double bonds at each end of each molecule, or four for each molecule, are as follows:—

Diagrams I, II and V, requiring four atoms of sulfur, give the molecular formula of caoutchouc as $(C_{10}H_{16})_{40}$, corresponding to $(C_{10}H_{16})_{40}S_4$.

Diagrams III and IV, requiring eight atoms of sulfur, give the molecular formula of caoutchouc as $(C_{10}H_{16})_{80}$, corresponding to $(C_{10}H_{16})_{80}S_8$.

Diagram VI, requiring two atoms of sulfur, gives the molecular formula of caoutchouc as $(C_{10}H_{16})_{20}$, corresponding to $(C_{10}H_{16})_{20}S_2$.

All these formulæ can be expressed by the general formula $(C_{10}H_{16})_n$ where n equals 20, 40 or 80; or by the formula $(C_{100}H_{160})_x$ where x equals 2, 4 or 8. The corresponding sulfur compounds would have the formula $((C_{10}H_{16})_{10}S)_x$.

Bary (loc. cit.) assumes that sulfur is divalent, and that the caoutchouc molecule is made up of a chain of $C_{10}H_{16}$ molecules joined together by their double bonds so that only two terminal double bonds remain free and unsaturated. Assuming only two such terminal double bonds, instead of four, the amount of sulfur required would be one-half that already indicated, and the molecular weight of caoutchouc would also be one-half of that corresponding to the foregoing formulæ. The same general formula, however, would still hold, the only changes being in the values of n and x in these formulæ, these values being n equals 10, 20 or 40, and x equals 1, 2 or 4, respectively.

The values of the molecular weights indicated by the above formulæ are as follows:

$$\begin{array}{ll} (C_{10}H_{16})_{10} \text{ or } C_{100}H_{160} & = 1,360 \\ (C_{10}H_{16})_{20} \text{ " } C_{200}H_{320} & = 2,720 \\ (C_{10}H_{16})_{40} \text{ " } C_{400}H_{640} & = 5,440 \\ (C_{10}H_{16})_{80} \text{ " } C_{800}H_{1280} & = 10,880 \end{array}$$

The molecular weight of caoutchouc in the latex has been determined by Hinrichsen and Kindscher, by the lowering of the freez-

ing point method, and found to be around 3,173, which corresponds closely to the formula $(C_{10}H_{16})_{23}$ (mol. wt. = 3128) (Ber., 1909, 42, 4329; *Jour. Soc. Chem. Ind.*, 1910, 34. See also Hinrichsen, *Zeit. angew. Chem.*, 1910, 23, 1345-7; *Jour. Soc. Chem. Ind.*, 1910, 1025).

Intermediate polymerization products between dipentene and caoutchouc were obtained by Weber in the spontaneous polymerization of isoprene, and by the depression of the freezing point method these products were indicated to have the formulæ $C_{33}H_{56}$ and $C_{40}H_{64}$, corresponding to the molecular weights 476 and 544, (*Jour. Soc. Chem. Ind.*, 1894, 13, p. 11).

It is interesting to compare these molecular weights with those which have been assigned to various other complex substances such as cellulose and albumin.

The formula of cellulose indicated by its nitro-derivatives is given by Weille as $C_{24}H_{40}O_{20}$, corresponding to a molecular weight of 648 (*C. r.*, 1882, 95, 132); while according to Skramp the smallest molecular weights indicated by the chlorine-acetyl derivatives are, for cellulose, 5508, and for starch, 7440. (Worden, *Nitrocellulose Industry*, Vol. I., pp. 25-26).

The molecular weights of various albumens as estimated by Schultz, assuming more than one atom of sulfur in each molecule, are as follows:

Serum albumin	5,100
Egg albumin	4,900
Oxyhemoglobin	14,800
Globulin	4,600

(Schultz, *Die Grosse d. Eiweiss-Molekuls*, G. Fischer, Jena, 1903; Abderhalden, *Text-book of Physiological Chemistry*, 1908, pp. 127-8).

From the properties and reactions of caoutchouc it seems improbable that any fixed and definite formula and molecular weight of general application can be assigned to it, but that the above possible formulæ indicated by the composition of vulcanized caoutchouc represent merely general averages, corresponding to the conditions of equilibrium at the vulcanization temperature.

The increase in solubility and decrease in viscosity of caoutchouc caused by prolonged mechanical working, or by prolonged

heating, and the larger amount of sulfur necessary for vulcanization of the caoutchouc so treated, can be satisfactorily explained only by assuming a depolymerization of larger molecular aggregates into smaller ones; while, on the other hand, the formation of synthetic caoutchouc takes place by the polymerization of smaller molecules to form larger ones. Synthetic caoutchoucs resulting from processes which have not proceeded to completion are apt to be of inferior quality, probably because of their low degree of polymerization, while if the process is carried out to completion, quantitatively, products of much higher degrees of polymerization appear to be obtained. Thus Kondakoff (*J. pr. Chem.* 64 (1901), p. 109) obtained from beta-gamma-dimethylbutadiene a quantitative polymerization product insoluble in all ordinary caoutchouc solvents.

Accordingly it seems probable that the size of the molecular aggregates varies in different caoutchoucs and even in the same caoutchouc under different conditions and that this size can be increased by allowing further polymerization or decreased by treatment, such as heating or working, which effects depolymerization. Under any given conditions, however, an equilibrium would tend to be established. At the temperature of vulcanization a partial depolymerization of the caoutchouc would be expected to take place, resulting in the formation of molecular aggregates stable at that temperature, and the above formulæ of vulcanized caoutchouc would represent the aggregates under such conditions. The size of the molecular aggregates at ordinary temperatures may very well be a multiple of that indicated by these formulæ.

As to the value of n in the general formula $(C_{10}H_{16})_n$ only speculation is at present possible. A theory such as assumed by Bary (loc. cit.) and by Hubener (*Gummi-Ztg.*, 1910, 627-9; *Jour. Soc. Chem. Ind.*, 1910, 289) requires a series of at least about ten, and at most about forty, eight-carbon rings joined to each other only at a single point or by a single double bond to form a long chain of rings. The theory set forth in the present paper requires at least about twenty, and at most about eighty, of the eight-carbon rings joined to each other, but with each ring joined to both adjacent rings by both its double bonds, as indicated in the photograph already shown. (The chemical union or

affinity between the double bonds is represented graphically by the crossed bonds in this photograph.) A molecule containing eighty of the eight-carbon rings is required only by a special combination of the sulfur, according to Diagrams III and IV, as already pointed out, and the very size and relative proportions of such a molecule would indicate it to be improbable. Twenty or forty rings in each molecule seem more probable, except where more or less complete polymerization of such molecules with each other were permitted to take place. A molecular aggregate made up of twenty or forty rings joined together in this manner by both double bonds would be expected to be a much more stable structure than one made up of a less number of rings joined only by a single bond. The stability and tensile strength of soft vulcanized caoutchouc would be more easily explainable by the former more stable structure. Moreover, this structure and the theory of its formation seem consistent with the various reactions of caoutchouc, including its further polymerization and its breaking down into smaller molecules.

The complete vulcanization of caoutchouc with sulfur requires, according to Weber, two atoms of sulfur for each $C_{10}H_{16}$ complex according to the formula $(C_{10}H_{16}S_2)_x$. One atom of sulfur must accordingly be present for each of the two double bonds of each eight-carbon ring. While one atom of divalent sulfur might combine with each such bond by first effecting depolymerization, yet it is desired to call attention to the possibility of tetravalent sulfur combining at each crossed bond to conjugate the two contiguous double bonds according to Diagram VI, previously shown. This is at least an interesting possibility, particularly if the valencies of tetravalent sulfur are capable of being

exerted at equidistant angles in the same plane, thus, $\begin{array}{c} | \\ -S- \\ | \end{array}$.

The molecular weight of synthetic caoutchouc probably varies much more than does that of the natural product. Little work has so far been done upon which any estimate of its degree of polymerization can be based. It seems probable, however, that the process of polymerization is a gradual and continuous process and gives ultimately a product comparable with the natural product. A similar process of gradual formation of natural caout-

chouc has been assumed by various writers to take place in growing rubber trees, resulting in products of higher polymerization and correspondingly greater value in the older trees.

Accordingly it is concluded that for ordinary natural caoutchouc the molecular aggregate at the temperature of vulcanization is represented approximately by the formula $(C_{10}H_{16})_{20}$ or by the formula $(C_{10}H_{16})_{40}$, and at ordinary temperatures by a multiple of such formulæ, while in the case of synthetic caoutchouc the molecule aggregate may vary within wide limits.

THE "BEF," A NEW THREE-WHEEL ELECTROMOBILE.

BY MAX DEITENBECK.*

There has been a tendency in all countries to manufacture a small automobile that would be in reach of a person of moderate means. This, of course, not only conditions a low first cost, but also a low cost of maintenance and the omission of the chauffeur. In the United States the manufacturers have turned out a small four-wheel gasoline automobile, while in Germany three-wheel automobiles are built to use electricity as well as gasoline for motive power. Both types have been a success for use in cities. One of the types driven by electricity is the "Bef," an electromobile built by the Berliner Electromobile Fabrik in Berlin, Germany.

The special feature of the "Bef" electromobile is the arrangement of the motor on the movable supports of the steering-wheel, and the application of the driving-gear to the steering-wheel.

In three-wheel motor cars of this type the proper placing of the motor is a matter of great difficulty. The motor is usually fixed to the front fork of the frame, which means the use of complicated accessory parts that are anything but ornamental, as they take up much space, disturb the balance of the car and make the steering heavy.

The manufacturers of the "Bef" electromobile have succeeded in removing these disadvantages and have arranged the axis of the electric motor in the same line as the axis of the steering movement.

Fig. 1 shows the form of construction. It is a section through motor, frame and steering-wheel and a side elevation of the same parts.

In the figure, (1) shows the casing of the motor, the axis of which is in line with that of the steering movement and passes

*Class of 1915. Mr. Deitenbeck has been with the manufacturers of the "Bef" as assistant manager and is at present representing their interests in the United States.

through the center of the steering-wheel. The front part of the frame is forked, the prongs passing around the motor and supporting it. The two clamping members (9) and (10) hold it in place and are bolted onto the prongs.

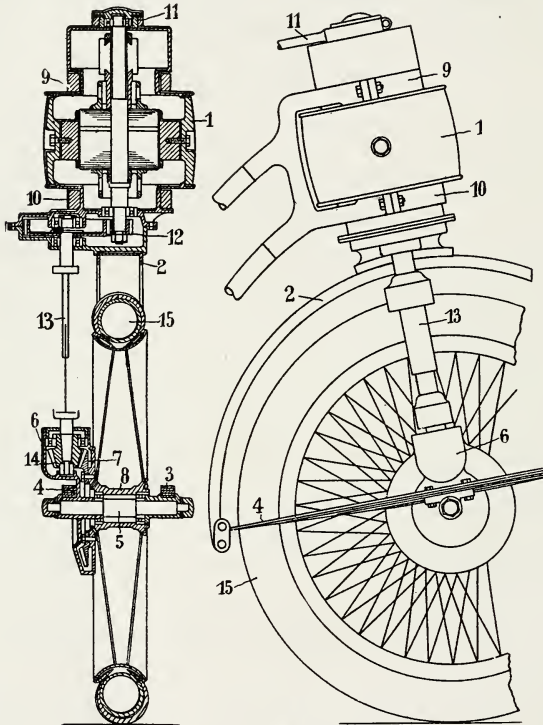


Fig. 1. Cross-Section of Motor and Driving Gear.

At the upper end of the steering frame is the casing of the motor. The motor shaft is hung on ball-bearings above and below in the casing (1) of the motor. At the lower end of the motor shaft is a cog-wheel (12) which engages in another cog-wheel on the counter shaft (13) parallel to the motor shaft. This shaft

(13) carries a bevel-wheel (14) at its lower end which engages in a corresponding bevel-wheel (7) fastened to the hollow hub (8) of the steering-wheel (15). The shaft (13) is fitted with a universal joint and consists of parts which can be pushed into one

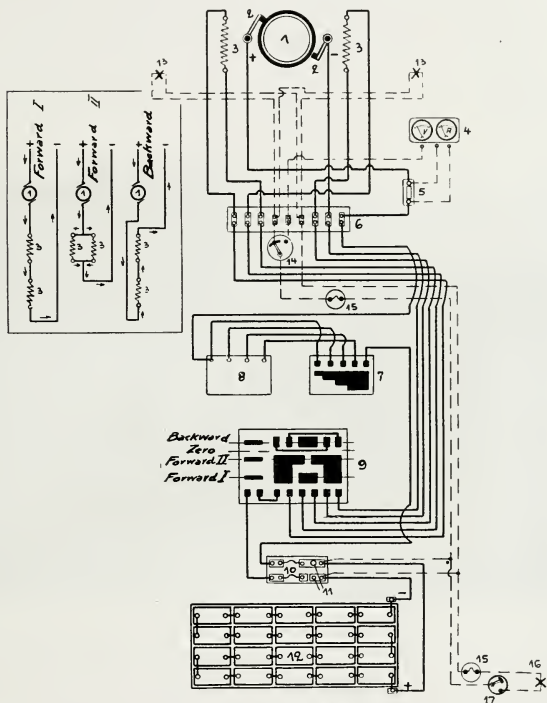


Fig. 2. Wiring Diagram.

another. The system of bevel-wheels is covered by the casings (5) and (6) of the front wheel. Both gearings of the axle are rigidly connected with the springs (3) and (4) on which rests the frame (2) which serves at the same time as a mudguard.

This form of construction has been patented in several countries, the number of the United States patent being 949828.

Fig. 2 shows the wiring diagram drawn so that it can be readily understood by the owner of a car, who in most cases is a layman.

The diagram shows the armature (1), the brushes (2), the field-coils (3), the voltmeter and the ammeter (4), the shunt (5), the terminal board (6), the starting and controlling apparatus (7) and (9), the carbon resistance (8), the fuses (10), the terminals for the charging of the battery (11), the storage-battery (12), the head lights (13), the switch for the head lights (14), the fuse for the lights (15); the rear light (16), and the switch for the rear light (17).



Fig. 3. Type of Electromobile Used for Delivery Purposes.

The motor is a 40-volt series motor which develops $2\frac{1}{2}$ brake horsepower at 1700 revolutions per minute.

The storage battery is of the pasted plate type and consists of 20 cells of 2.2 volts each. It is placed under the front seat. One charge will suffice for 45 to 65 miles with a speed from 10 to 15 miles per hour, according to the type of the car.

Each car is provided with two independent foot-brakes. One is a band brake and the other is a clutch. The weight of the car ranges from 1,300 to 2,000 pounds. The weight of the storage battery is 575 pounds. The loading capacity of the car is up to

1,100 pounds. All revolving parts are encased, which keeps out the dust and prevents the flying of the lubricant.

The handling of the car is very simple. The cylindrical starter (7), Fig. 2, is revolved by foot, thus switching in all the resistances (8). A lever on the side of the car, revolving the controller (9), is brought forward into the position for the first (slow) speed. The current then flows through the motor as shown in "Forward 1." By slowly releasing the starter all resistances are successively switched out and the car moves with the full first speed. To gain the higher speed the resistances are switched in again and the lever is brought to the second position,



Fig. 4. Type of Electromobile Used by Fire Departments.

at which the current will flow as indicated in "Forward 2." This time the starter must be released quickly, so as not to decrease the velocity of the car too much. To reverse the motion of the car the lever is thrown all the way back, which simply reverses the flow of the current. To lower the speed, as for instance at street curves or corners, it is only necessary to revolve the starter which varies the speed by forcing the current to flow through some of the resistances. By applying both brakes and the back motion it is possible to bring the car to a dead stop within three feet.

In the first cars built the steering was done by a handbar rigidly fastened to the motor casing. But on account of an ordinance in

Germany, which requires all automobiles above a certain weight to be equipped with a steering-wheel, all the later built cars have a steering-wheel which acts directly on the front wheel. The front or steering-wheel can move through such an angle that the car can describe a circle 18 feet in diameter.

The cost of maintenance is low. The manufacturers claim it to be as follows, the figures giving the cost per mile: Current, $1\frac{1}{4}$ cents at 4 cents per kilowatt-hour; tires and tubes, $1\frac{3}{4}$ cents; maintenance of storage battery, $1\frac{3}{4}$ cents; general repairs, $1\frac{1}{4}$ cents.

"Bef" electromobiles have been used to great advantage in many cities in Europe, as well as in other countries, and have given excellent service everywhere. The German postoffice department is using the "Bef" extensively for the transportation of letters and packages and for the collection of mail from letter-boxes. Fig. 3 shows one of the cars used in this work. The police department of Berlin owns a number of cars which are in use for the transportation of corpses. Several cars are also used by the fire departments of various cities. Fig. 4 shows a car equipped with an oxygen apparatus owned by the fire department at Dusseldorf, Germany. Many stores and business concerns make extensive use of these cars for delivery purposes, and some cars of the brougham type are used as taxicabs in Hungary. It may be said, however, that the "Bef" electromobile is better suited for the transportation of goods than for the transportation of passengers.

HIGH-TENSION DIRECT-CURRENT TRANSMISSION.

BY FRANCIS FERNANDEZ.*

High tension electric power transmission may be considered as being in the primary stage of successful application and development. Therefore it cannot be said offhand which system of transmission is best adapted for all conditions. The highest obtainable working pressure and the limit so far as distance of transmission is concerned are factors which are being continually improved, and they are still under the possibility of further improvements.

Two systems have first entered competition for high-tension transmission: the three-phase and the single-phase alternating current systems. Distance of transmission has shown a tendency of favoring the former one and traction the latter. About twenty-three years ago another system endeavored to enroll in this competition, but distrust and favoritism have kept it from growing. In spite of this drawback, the remarkable success of a number of high-tension transmission installations at the present time have placed this system as a strong competitor to the three-phase and single-phase systems, both for long distance transmission and traction. This is the system of high-tension electric power transmission by continuous current.

This system has been almost entirely of European practice, and most of the plants using it are serving at the present time as a positive proof (although the application is relatively rudimentary) of what can be done with direct current transmission. Among the most notable of them is the Montiers-Lyons transmission line, 224 miles long (112 miles each way), using an impressed voltage of 57,600 volts, and with a double maximum voltage under future construction. Also must be mentioned the projected plant to transmit 20,000 kilowatts at 90,000 volts from

*Class of 1914. A. B., 1907, Buenos Ayres National College, Buenos Ayres, Argentina.

Trollhättan, Sweden, to Copenhagen, Denmark, across the Strait of Oresund, $3\frac{1}{2}$ miles wide. The decision in regard to this system came after a very thorough comparison with the three-phase alternating current transmission system as to simplicity of insulation, steadiness of load, higher permissible working pressure in submarine cables, and total costs; the total cost of the two systems considered were \$1,593,000 for the three-phase system and \$1,202,000 for the direct-current system.

Thury has successfully applied to this high-tension continuous current system the principle of the direct-current series arc lighting system with a few modifications, and the system is now justly known as the Thury system.

The system consists of a closed loop using constant current with all the generators and motors in series. The motors at the delivery stations may be used to drive generators connected to a parallel system supplying energy to industrial areas.

Each generator and motor is provided with a short-circuiting switch, which can be operated either by hand or by automatic regulators, these switches being used to throw in or out each generator or motor from the circuit. All the generators and motors on the main circuit—that is, on the series constant-current circuit—are series-wound machines. Each machine is highly insulated from the ground by concrete and asphalt foundations and rests on porcelain insulators; flexible insulating couplings constitute the insulation from the prime movers and driven machinery.

Since the generators are constant-current machines, the prime mover best fulfilling the conditions for driving these generators is one which produces a constant torque, as hydraulic machines without reservoir and steam engines with constant cut-off and steam pressure. As for the motors, since they are also series-wound machines, they are of constant torque with constant current. The torque varies as the armature current, and in a series machine the magnetic flux varies proportionally to the armature current. Therefore, when the load at the receiving station increases the current increases, which will cause the prime mover to slow down, due to increased driving torque. The decrease in speed decreases the e. m. f. of the generator or generators, which in turn lowers the current. When the current decreases through a decrease of load on the motors the prime mover speeds up and

the original value of current is obtained. Under this ideal condition the generators would be self-regulating, but in practice there are a few imperfections in operation which necessitate the use of certain devices for regulating the current delivered by the generators and the speed of the motors as the load changes.

There are various practical ways of regulation. Speed regulation of the prime movers may be effected by regulators placed in parallel with the main circuit, so that the controlling current can be easily adjusted. This current passes through a solenoid acting on a mechanism which operates the regulator itself. The regulation is so perfect that usually only one regulator is necessary for all the turbines; but if central ground is used two regulators are needed. This alone is one of the great saving factors in favor of the Thury system. Regulation by changing the speed of the prime is very favorable when hydraulic turbines without reservoir are used, since the operating efficiency of the prime mover in this case is independent of the speed. On the other hand, this method of regulation does not apply advantageously to hydraulic turbines with reservoir and to steam turbines, in which the efficiency varies directly as the speed. In the latter case some other method of regulation is necessary: either by changing the flux, by shifting the position of the brushes on the commutator, or by a combination of these two methods.

Regulation by changing the flux may be affected by adjustable shunts in the field winding, so that only a certain fraction of the main current passes through the winding. The disadvantage of this method is that armature reaction will relatively increase to such a value that very serious sparking will result. The practical limit of operation is to shunt less than one-third of the total current, which value will reduce the e. m. f. only 66 per cent. By shifting the brushes from the commutating plane some of the coils of the winding will produce a pressure opposing the pressure produced by the coils on the other side of the brushes; thus the pressure will decrease as the displacement of the brushes from the commutating plane increases. The effect of armature reaction may be neutralized by applying the principle of the interpole system. In the Thury generators the action of the interpoles is produced by the main field winding in which the ampere-turns are adjusted to produce the required effect of the interpoles when connected on the parallel system. The com-

bination of changing the magnetic flux and shifting the position of brushes on the commutator is very advisable for small variations of load. If a large variation is required more generators are connected in series on the line.

There is no self-regulation in the motors. Since the torque is constant with constant-current supply any decrease in load will cause the motor to increase in speed and tend to run away, and a reversed action takes place when the load increases. Moreover, the efficiency of the motor varies with the speed, and if the motors are used to drive generators at sub-stations for local distribution the secondary e. m. f. would fluctuate heavily if the speed of the motors varied with the load. Speed regulators become essential in order to keep the speed of the motors constant.

Speed regulation in the motors is accomplished by either changing the flux, shifting the position of the brushes or by a combination of both methods. The action of each of these methods of speed regulation is the same as in the case of generators. For this reason the combination method is to be preferred. The device for the speed regulation is operated by a small centrifugal governor mechanically connected to the motor shaft, and through an intermediate mechanism changes the shunting resistance of the field winding and rocks the brushes.

The operation for switching in or out a generator is very simple. The machine is first brought up to the required speed and the field adjusted for the line current, then short-circuiting switch is opened and the generator takes care of its own regulation.

This system has the advantage of not requiring any starting rheostat for the motors. The operation for starting a motor consists in placing the brushes in the neutral position and opening the short-circuiting switch; then, by gradually moving the brushes, the motor is brought up to the desired speed. The operation for switching out a generator or stopping a motor is the reverse of the one just given.

Since any of the generators can be connected or disconnected from the system it is not essential that all the generators should have the same rated voltage. Each generator will take its proper share of the load; but, in order to have a uniform distribution of load over all the generators, it is advisable to have all the generators in the main circuit of the same rated voltage.

The small variation in efficiency of the constant-current series motor on large variations of load can be shown by figures obtained from actual tests on this type of motor: For the rated output, 935 horsepower of a test motor the efficiency was 95 per cent; for a decrease of 561 horsepower the efficiency decreased only 3 per cent, and for a decrease of 845 horsepower the efficiency was lowered only 15 per cent; that is, for 90 horsepower the efficiency was 80 per cent. The curve showed a remarkable constancy in efficiency as the load was varied.

The sparkless commutation of these motors, the absence of starting rheostats and the reversibility of operation, either as a generator or as a motor, has placed this type of motors as the ideal one for driving mining machinery.

The generators, as well as the prime movers, are equipped with protective apparatus; an over-voltage short-circuiting switch in case the pressure rises beyond the safe limit; an inverse-rotation-short-circuiting switch, which operates automatically on reversal of rotation, in case of failure of one of the prime movers, the generator becoming a motor. If a short-circuit occurs in one of the generators the prime mover would receive a severe shock. In practice this is generally remedied by providing each generator with a slipping coupling. The only protective apparatus required for the motor is an overvoltage short-circuiting switch, which operates automatically, in case of heavy overloads.

There are three different schemes for the transmission lines: two insulated wires with two central grounds; one insulated wire with grounded return, and two insulated wires.

In the system using two insulated wires with two central grounds the principle is the same as that of the three-wire system, having a few additional advantages to that system. The neutral connection in this case is the earth. Central grounds are made at each end of the two transmission wires and one at the middle point of the generators, and they are so placed so as to balance the load as well as possible on each side of the grounds. In this way the voltage across the two wires may be doubled with safety, since the pressure between the wire and ground is always within one-half the maximum transmission pressure. One of the disadvantages of this transmission scheme is evident when an accidental ground occurs; then the part of the main circuit between the side of the ground opposite to the generating station

and the following ground will be short-circuited and put this section out of operation. In order to reduce the time which would take to repair a short-circuit, some means of shifting grounds is provided to the main circuit.

The second scheme for the transmission lines is to use one insulated line and the ground as the return line. Within an economical distance it is possible to use the earth as a return conductor, which for its low resistance and great reduction of line cost is very convenient. The greatest resistance of the ground conductor is found to be between the grounding plates and ground. From tests made on the St. Maurice-Lausanne transmission system the following results were obtained: With a line 35 miles long the total ground resistance was only .5 ohm, and a current in the neighborhood of 100 amperes gave no trouble with the ground return. On the other hand, this scheme is handicapped by possible grounding that may occur, thus short-circuiting the rest of the transmission line. This, of course, requires higher insulation of the entire system. By using two insulated wires there is a gain both in insulation and in facility with which repairs on the main circuit can be made and a loss in the maximum line pressure, which is limited by the capacity of the two transmission wires. The gain in line insulation over the grounded system is due to the fact that if any single ground occurs no discontinuity of service will be observed; therefore the lines need not be so highly insulated from the ground as in the case of grounded system. To repair the line two grounds, one on each side of the point where the trouble occurs, may be made and the work carried out with great facility and without affecting the continuity of service. The entire system is protected against sudden rise of pressure, as in the case of lightning, by providing the line with lightning arresters so regulated as to keep any rising voltage within safe limits. The effectiveness of these lightning arresters is increased by the use of choke coils, which introduce no other loss than the very small increase in ohmic resistance.

There are two types of lightning arresters: the discontinuous or disruptive and the continuous or conductive arresters. In the discontinuous type one or more spark gaps, either in air or in oil, are used, and they are connected either across the mains or between one of the mains and the earth. The spark gaps are arranged either in series or in parallel groups and when working

at high pressures there will be a leakage, known as brush discharge, which represents a loss through the lightning arrester. In the continuous type, which is more effective than the former one, the mains are kept in contact with the earth by jets of running water, through which there is an appreciable leakage current loss. It is not good practice to use safety apparatus at equal distances along the line, but only at those points requiring protection.

Among the requirements to fully protect the lines are large air-gap lightning arresters, set so that they will act at a pressure five times the normal pressure; multiple gap arresters with resistance in series to act at twice the normal pressure; continuous arresters of the hydraulic type taking from 0.2 to 0.5 ampere, and arresters between mains closed to junction to protect machines from sudden rise in pressure caused either by lightning or large variation of load.

Line economy is one of the most important items to be considered in connection with the Thury system. This can be best shown by a relative cost of continuous current, as compared with three-phase alternating current transmission lines. In order to make the comparison possible some assumptions have to be made. Let the power transmitted, length of transmission, line insulation and line loss be the same in both the Thury and three-phase systems. It is further assumed that the e. m. f. follows the theoretical sine wave and that the power factor is 0.8. Then under these conditions the line cost will be:

When the maximum pressure between line and ground for both systems is the same, the direct-current line cost will be 32 per cent of the alternating-current line cost.

When the pressure between lines on each system is the same, the direct-current line cost will be 42.6 per cent of the alternating-current line cost.

When the direct-current voltage to ground is double the alternating-current voltage to ground, the ratio of the direct-current to the alternating-current line cost will be 0.16.

When the direct-current voltage between lines is double the alternating-current voltage between lines, the ratio of the direct-current line cost to the alternating-current line cost will be 0.213.

As to the number of insulators required, the direct-current series system using neutral grounds will be two-thirds of that

required for the three-phase system. If a ground return is used, the number of insulators needed will only be one-third of that required for the three-phase system.

The economy in insulation is evident from the fact that direct-current high-tension transmission is high tension only near the generating station. On the other hand, alternating-current transmission is high tension all along the line. For this reason high insulation is required throughout the entire line of the alternating-current system.

In the Thury system the line loss is constant for all loads, since the current supplied is constant; therefore, the percentage line loss will vary inversely as the load. In the alternating-current parallel system the line loss varies directly as $I^2R/EI \cos \phi$; that is, as the load, provided E and $\cos \phi$ are constants.

From these considerations the possible superiority of the Thury system can be clearly seen when all the power is transmitted in bulk, and the greater advantage to be obtained when the sub-stations are concentrated at the farther end of the line. Moreover, tests have proved that insulating materials had less temperature rise when subjected to high direct-current voltage than when subjected to alternating-current voltage; that the voltage required to puncture with direct-current was more than twice the alternating-current voltage. Sparking distance was found to be about one-half for a given pressure in favor of the continuous current. These tests show that a given transmission line can be used to transmit continuous current at twice the maximum pressure.

The cost of direct-current machines and the great number of them needed, due to their relative low terminal voltage, as compared with the alternating-current machine, greatly favors the alternating-current system. The highest pressure per commutator which has been obtained is about 4,000 volts and a probable output of from 1,000 to 2,000 kilowatts. It is claimed, however, that there is possibility of building direct-current machines with a capacity of 10,000 volts and 100 amperes.

When the power is transmitted in bulk over wide areas and the transmission lines provided with central grounds, breakdowns in the line can be easily repaired by grounding the next sub-station toward the generating plant on the side opposite to the generating station. Then only the sub-stations between this

ground and the line central ground will be short-circuited while repairs are being made. But if the breakdown occurs near the generating station, most of the sub-stations would be short-circuited.

To insure continuity of service in all the sub-stations an additional line cost is to be preferred, by making use of a reserve wire connected in parallel between the power house and the middle point of the transmission lines. This reserve wire can be switched on either side of the lines or disconnected entirely from the system. This is the scheme used for shifting the central grounds, together with grounding cabins provided to each sub-station. The principle on which this scheme is based is that there must always be an equal number of sub-stations on each side of the central grounds in order to keep the balance on each side of the line. If a breakdown occurs beyond the middle point of the transmission line no reserve wire will be needed and the central ground is simply placed in one of the grounding cabins at one of the sub-stations, so that the balance of load will be maintained.

If the breakdown occurs nearer the power house the reserve wire is connected to the side of the line where the trouble is located and the ground changed to one of the sub-stations so as to have an equal number of sub-stations on each side of the line.

A resume of the advantages and disadvantages of the Thury system is given as follows:

The advantages are: The permissible maximum pressure which can be used with the Thury system is about twice that used with alternating current. Cost of transmission lines, distance of transmission, behavior of insulating materials, and percentage line loss, because of unity power factor, all favor the installation of a direct-current system. Underground and submarine transmission of electric energy are better accomplished by the use of the Thury system. Losses through dielectric hysteresis, induction capacity and rising pressures due to resonance are eliminated by the use of continuous current. Necessary switching gear is of greater simplicity; all that is required for each generator is a switch pillar with a short-circuiting switch, an ammeter and a voltmeter. As the power output varies the number of generators or generating stations can be increased or decreased with great ease.

The disadvantages are: Relative low capacity of direct-current machines and low voltage per commutator; therefore, higher cost

of generating machines for a given output. Need of insulating floors, mountings and couplings. Large percentage power loss on light loads. Motors cannot be overloaded. Necessity of speed regulators for motors. Greater liability of damage from lightning. The system is only efficient for bulk transmission of power and for distribution at the farthest end of the line. Limitation of types of turbines, only the horizontal type being adaptable; water turbines using a storage reservoir, with constant working head, are not suitable as a source of power for the Thury system.

Judging from the improvements made during the past year in the transmission of high-tension direct current, it may be said that many disadvantages of the system will probably be overcome, and Thury's method of transmission placed as an ideal one before long.

OPPORTUNITIES FOR THE TECHNICAL MAN IN PUBLIC SERVICE.

BY F. G. HEUCHLING, CH. E.*

Members of the engineering and allied professions are generally of the opinion that the public service—whether it be federal, state or municipal—offers to persons who enter it little promise of remuneration or promotion. The idea is also prevalent that politics and personal favoritism play a large part in the success of the individual public employe. This feeling has developed because of the conditions which existed throughout the public service during the period before the application of civil service laws, and which prevail to a certain extent in some municipalities at the present time.

The purpose of this article is to point out the many profitable opportunities offered to the technical man in the public service, and to outline the merit system which is being applied with ever-increasing thoroughness in the federal, state and city services throughout the country. Each new recruit who enters the public service from the ranks of conscientious, technically trained men adds one more element toward the efficient and economical conduct of public work. If a few such recruits enter the public service as a result of reading these lines, or are assisted to that end by the information contained herein, the desired object of this article will have been attained.

The opportunities offered by the civil service of the City of Chicago will be first described, because they are of greatest local interest. The features of the service of the State of Illinois which are of interest to the technically trained man will then be described, with a few statements regarding the services of the park systems in the City of Chicago. Only the more important features of the Federal Civil Service can be mentioned because of lack of space. A few remarks will also be added concerning

*Class of 1907. Superintendent of Employment, West Park Commissioners, Chicago.

examination standards and rules and certain factors which are taken into account in almost every civil service examination.

Service of the City of Chicago.

All employes of the City of Chicago, with very few exceptions, are protected in their places by a civil service law enacted by the Legislature of Illinois in 1895. The city appropriation bill for 1913 provides for the employment of 14,935 persons in the civil service. The civil service law requires the Civil Service Commission, which consists of three members appointed by the Mayor, to classify the positions in the service "with reference to examinations."* This classification is based on the duties of the positions included, and establishes classes, in each of which are placed all positions whose duties are of a similar character. Within each class the positions are divided into grades or ranks according to importance, authority and responsibility.

Nearly all the technical positions in the city service are placed in Class "B," which is known as the Engineering Service. This includes field and office engineering positions, whether they be mechanical, electrical, civil, architectural or chemical. There are 352 positions in this class, occurring in twelve different departments of the service. The average salary has been calculated as \$1,843 per year. The maximum salary is \$8,000 per year, which is paid to the City Engineer and to the Architect of the Board of Education. The minimum is \$1,080 per year, at which figure rodmen, draftsmen and engineering laboratory assistants must start when they enter the service in the lowest grade. It is well to note at this point that the rules of the Civil Service Commission, which will be more fully described later, make it possible for a man who enters the service as a draftsman or rodman at \$1,080, to gain promotion to the highest positions in the service. A number of examples could be cited, if space permitted, where city employes have nearly doubled their salaries in the space of three or four years, by virtue of this promotion scheme.

In addition to the positions in Class "B," there are many other positions of interest in Class "H," Inspection Service, and Class "E," Operating Engineering Service. Class "H" includes all positions whose duties consist of the inspection of materials or conditions, but which do not require technical training. The

*Hence the term "Classified service," which is applied to all the positions, taken collectively, which are under civil service and which must be filled by examination.

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positions in this class include electrical inspectors, paving and sidewalk inspectors, boiler inspectors, sanitary and plumbing inspectors, and numerous other places, totaling 728 positions in the entire class.

Class "E," the Operating Engineering Service, includes all positions in the water pumping and the sewage pumping stations, as well as those of the school engineers in the public grammar and high schools. The lower grades of this class include oilers, water tenders and mechanical assistants at \$1,080 to \$1,200 per year, and the highest grade includes the chief operating engineers at pumping stations, the Public Library and City Hall, who are paid \$2,500 per year. There are 576 positions in this class.

Bureau of Engineering.—The majority of the positions in the Engineering Service (Class "B") are found in the Bureau of Engineering of the Department of Public Works. The entire department is headed by the Commissioner of Public Works, who is appointed by the Mayor and is not under civil service. The Bureau of Engineering is the most important branch of this department and is in charge of the City Engineer. The position of City Engineer, as well as all other positions in the Bureau of Engineering, is in the classified civil service and must be filled by examination, with the exception of a few Harbor Masters and Vessel Dispatchers. Directly under the City Engineer there is one Assistant City Engineer, who is in touch with all the work of the Bureau and responsible for its progress in the absence of the City Engineer.

The work of the Bureau of Engineering may be described under six heads, corresponding to the six divisions of its organization. These are illustrated by charts I and II, which are reproduced from a publication of the Chicago Civil Service Commission. These charts show all the positions in the Bureau, giving in each case the civil service class and grade of the positions, the number of positions and the yearly salary of each. Each rectangle on these charts represents positions of one title. Directly under each title, at the left-hand side, is given the civil service class and grade, and at the right-hand side the number of such positions and the salary of each. The vertical lines represent lines of authority, persons in positions lower down in these lines

being under the authority and direction of persons in positions shown above them.

The six divisions of the Bureau are known as the Division of Bridges, Viaducts and Harbor, the Division of Waterworks Construction, the Division of Tests, the General Office Division, the Division of Water Pipe Extension and the Division of Pumping Stations and Shops.

The Division of Bridges, Viaducts and Harbor, headed by the Engineer of Bridges and Harbor and the Assistant Bridge Engineer in Charge, is divided into seven sections. The Clerical Section maintains the office records and accounts. The Harbor Section is subdivided into two branches. One branch, in charge of the Harbor Master, polices the river and harbor, inspects and dispatches all shipping done by water, and keeps records and statistics of the lake commerce. The other branch, in charge of an Assistant Engineer, makes soundings, prepares surveys and handles repairs and replacements to piers, wharves and breakwaters, and supervises dredging operations. This branch includes one Junior Engineer and two Rodmen, in addition to the Assistant Engineer in charge. The Designing Section, headed by the Engineer of Bridge Design, makes all plans and draws all specifications for bascule, rolling lift, and center pier swing bridges, as well as reinforced concrete and timber structures for the outlying districts of the city. A Mechanical Designing Engineer is employed in this section for the design of the machinery for movable spans. The nature of the work of the other positions in this section is indicated by the titles shown on Chart I. The Bridges and Viaducts Section, headed by the Engineer of Bridge Construction and Repairs, includes all the mechanics and skilled laborers assigned to maintenance and repair work, as well as the forces engaged in the replacement of wornout parts and minor structures. The Operating Section consists entirely of the bridge tenders. The Viaduct Inspection Section, as its name implies, handles the inspection of railroad and other viaducts in order to insure the proper maintenance and repair of these structures, and also inspects the construction of new work of this character. The Construction Section handles all field engineering work in connection with the construction of new bridges, including preliminary surveys, field estimates and the inspection of contract work. This section includes two Assistant Engineers, three

DEPARTMENT of PUBLIC WORKS
BUREAU of STREETS

Junior Engineers and three Rodmen, with other help as the work requires.

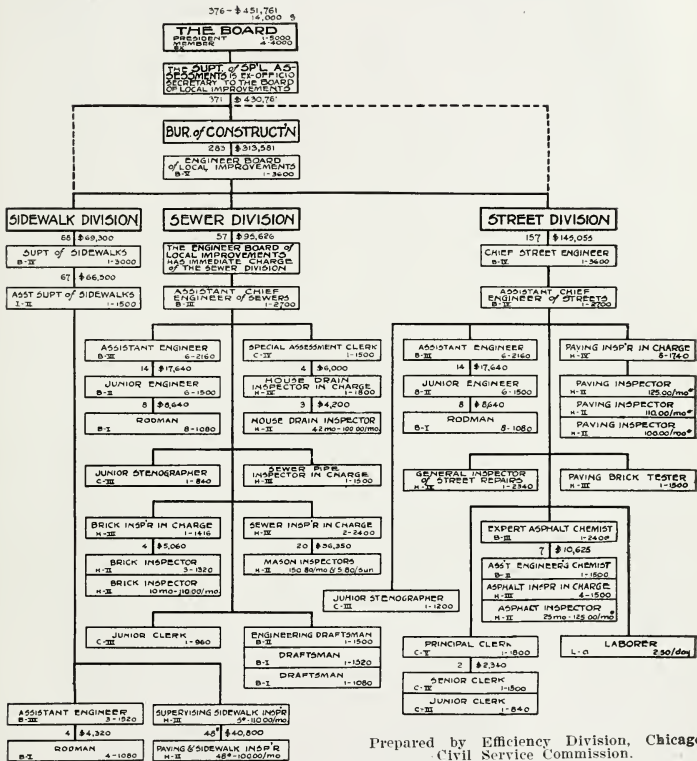
The Division of Water Works Construction handles all work in connection with water works, exclusive of the pumping machinery and auxiliaries, and is in charge of the Engineer of Water Works Construction. All new pumping station buildings, or additions to present buildings, all water tunnels or conduits, and all cribs and intakes are designed by the office force, which is known as the Designing Section and is under the Engineer of Water Works Design. The field work, including inspection, surveying and laying out, is carried on by the Division of Construction.

The Division of Tests handles the analysis and mechanical testing of all materials used by the Bureau of Engineering, as well as some of those used by other bureaus and departments of the service. A well equipped laboratory is operated at the Chicago Avenue Pumping Station. Here all the coals and lubricating oils used in the pumping stations, all the paints and pigments used in the maintenance work, are analyzed and all the cement and concrete materials are tested, as are also the cast iron and steel used in machinery and structural work. This division is in charge of an Engineering Chemist.

The General Office Division handles only the accounting and administration work of the Bureau.

The Division of Water Pipe Extension, as its name implies, is the organization which is engaged principally in the construction of additions to the water distribution system and replacements in obsolete or worn out water mains. The entire division is headed by the Superintendent of Water Pipe Extension, whose position is classified in the Engineering Service (Class "B") and who is therefore required to be an engineer. The actual construction work is done by the field forces of the Construction and Maintenance Section of the division. This section is in the charge of the Assistant Superintendent of Water Pipe Extension, who assigns the field jobs to the various gangs and crews. The clerical work is performed by the Clerical Section, and the stock receiving, storing and issuing is done under the direction of the Superintendent of Pipe Yards, who has a number of storage yards situated in various parts of the city. The preparation of plans and estimates and the inspection and supervision of the

BOARD OF LOCAL IMPROVEMENTS, CHART IV.



Prepared by Efficiency Division, Chicago
Civil Service Commission.

field work is taken care of by the Engineering Section, which is in the charge of an Assistant Engineer. This section is also responsible for the inspection of all materials delivered for use in its work and has inspectors located at the various foundries and mills where the pipe or other material is being made. The Plumbing Inspection Section, headed by the Plumbing Inspector in Charge, is required to pass on the service pipes and connections in all premises before the pressure from the mains is applied. The tapping of water mains for connection to private service pipes is done by the Tapping Section. A very important function of the Water Pipe Extension Division is the conduct of extensive studies of water waste and of electrolysis of the distributing mains. These studies are carried on by the Water Survey Section, which is headed by the Engineer of Water Surveys. This section is also required to keep in close touch with the needs of the various parts of the city with respect to water supply, in order that new pumping stations, water tunnels and supply mains may be properly located.

The Division of Pumping Stations and Shops is one of the most important branches of the Bureau of Engineering. It is headed by the Mechanical Engineer in Charge, who is paid a greater salary than any other officer of the bureau except the City Engineer. The division is divided into six sections, known as the Designing Section, the Operating Section, the Crib Section, the Meter Shop Section, the Water Works Shops Section and the Clerical Section. The Designing Section includes a Mechanical Designing Engineer and Mechanical Engineering Draftsman, engaged in the making of plans and estimates for new or proposed pumping station machinery, or for repairs and replacements. The Operating Section includes separate crews for operating each of the twelve pumping stations in the city. Nine of these crews are headed by Chief Operating Engineers, who receive \$2,500 per year, and the other three are headed by First or Second Assistant Operating Engineers, who receive \$2,000 and \$1,560 per year, respectively. The Crib Section is headed by the Engineer of Water Surveys, who is also in charge of the Water Survey Section of the Water Pipe Extension Division. This section mans and maintains the various intake cribs in Lake Michigan. The Meter Shop Section, headed by the General Meter Foreman, makes all repairs on water meters and

installs new or overhauled meters in the supply systems. The Water Works Shops Section, in charge of the Superintendent of Water Works Shops, makes all repair parts for the pumping machinery and distributing system. For this purpose a very extensive machine shop is operated, situated at Blue Island avenue and Twenty-second street. This section also performs all steam-fitting for the pumping stations and all painting, carpentry, and other maintenance and repair work for the station buildings. The Clerical Section is engaged on office records.

Bureau of Streets.—Another important branch of the Department of Public Works is the Bureau of Streets, which is headed by the Superintendent of Streets, who is required to be an engineer. Although the work of the bureau touches upon many important engineering problems, the First Assistant Superintendent of Streets, who handles principally administration questions, is not required to be an engineer. The functions of the bureau include (a) the inspection and supervision of all openings made in paved streets for the laying of service pipes, conduits and the like, which work is handled by Public Utility Inspectors in the Permit Section of the bureau; (b) the cleaning of streets and alleys and the hauling and disposal of garbage, ashes and refuse, which are done by the Ward Superintendents and their forces in the Division of Street and Alley Cleaning; (c) the repairing and replacing of street pavements, done by the Division of Street Repairs, which is below described; and (d) the clerical work and record keeping required as a result of the activities of the other divisions of the bureau, which is handled by the Clerical Division.

The Division of Street Repairs includes all the engineering positions and will therefore be more fully described. The head of the division, known as the Third Assistant Superintendent of Streets, is required to be an engineer and receives \$3,600 per year. He has under him one Assistant Engineer at \$1,920 per year, four Junior Engineers at salaries ranging from \$1,500 to \$1,740 per year, and four Rodmen, who receive from \$1,080 to \$1,320 per year. This force inspects and supervises the field work and fixes lines and grades for the construction and repair forces. The paving materials are passed upon by an Engineering Chemist, who receives \$2,000 per year. All the work of this division consists of repairs to pavements, road oiling and other dust

preventive operations. Most of the funds for the work of the division are derived from the wheel tax receipts. All the new pavement work is paid for by special assessment taxes, and is done by the Board of Local Improvements, which maintains a separate and distinct organization.

Bureau of Sewers.—The Bureau of Sewers of the Department of Public Works, headed by the Superintendent of Sewers, handles the maintenance and repair of the sewerage system and the operation of the sewage pumping stations. The construction of new sewers is left to the Board of Local Improvements, as in the case of new street paving, and is paid for by special assessment taxes. The Bureau of Sewers includes Divisions of (a) Pumping Stations, (b) House Drain Inspection, (c) Sewer Repairs, (d) Benches and Grades, and (e) Sewer Cleaning. Only the Divisions of Pumping Stations, Sewer Repairs and Benches and Grades include engineers in their organizations. The first consists of operating crews for each of the sewage pumping stations, each crew being in charge of a First or Second Operating Engineer in Charge, paid from \$1,560 to \$2,000 per year. The Division of Sewer Repairs includes an Assistant Engineer at \$2,160 per year, three Mason Inspectors at \$1,800 per year each, and one Rodman at \$1,080 per year. The Division of Benches and Grades, which provides for the proper fall and elevation of sewers, includes one Assistant Engineer at \$2,500 per year, one Junior Engineer at \$1,800, and two Rodmen at \$1,080.

Bureau of Architecture.—The Bureau of Architecture, headed by the City Architect, who is under civil service and receives \$4,500 per year, handles all the architectural work for the city. An Architectural Designer at \$2,000 per year, six Architectural Draftsmen at \$1,500 per year each, and two Assistant Architectural Draftsmen, are regularly employed here, in addition to inspectors and other draftsmen for emergency work.

Bureau of Maps and Plats.—The Bureau of Maps and Plats is also a part of the Department of Public Works, and is charged with keeping records of real estate subdivisions as well as maps of the entire city, showing the streets and alleys and the lots into which each block of property in the city is divided. The bureau is in charge of the Superintendent of Maps, who receives \$4,000 per year and is required to be an engineer. Under him there are

a Chief Draftsman at \$1,740 per year and twenty-one Map Draftsmen, who are paid from \$1,080 to \$1,500 per year.

Board of Local Improvements.—The Board of Local Improvements has complete charge of all new street and sidewalk paving and sewer construction. It maintains a separate organization and is directly responsible to the Mayor. All the work is done by contract, and special assessment taxes are levied on the owners of property in the vicinity of the improvement for defraying the expenses. The engineering work is handled by a Sidewalk Division, Sewer Division and Street Division, all of which are under the direction of the Engineer of the Board, who receives \$3,600 per year. A very complete engineering force is employed for the purpose of making plans and estimates, preparing specifications, fixing street, sewer and sidewalk lines and grades for the construction forces, and inspecting and supervising all field work. The organization maintained for this purpose is shown on Chart IV, which also indicates the title, number and salary of all positions.

Board of Education.—The positions in the Board of Education which are of interest to the technical man, and which are included in the classified civil service, are as follows: The Chief Engineer of the Board, who receives \$5,000 per year, his assistant, who receives \$4,000, a Heating and Ventilating Designing Engineer at \$2,400 per year, an Electrical Designing Engineer at \$2,400 per year, a Sanitary Designing Engineer at \$1,920, and two Draftsmen at \$1,200 per year. These persons are engaged on the design and inspection of new heating, lighting, ventilating and sanitary construction work for school buildings, as well as the supervision of the engineer-janitors who operate the present equipment. The Bureau of Architecture of the Board of Education also maintains an extensive architectural force. The Architect for the Board is under civil service and receives \$6,000 per year. His assistant receives \$4,000 per year. A Superintendent and four Assistant Superintendents of Construction are employed at salaries ranging from \$2,600 to \$3,200 per year. The office forces are in charge of a Chief Architectural Designer, who receives \$3,600 per year, and who has under him thirteen Architectural Engineers, Designers and Draftsmen, at salaries ranging from \$1,620 to \$2,400 per year. Five Assistant Archi-

tectural Draftsmen are also employed at \$1,080 to \$1,700 per year each.

Department of Track Elevation.—An important engineering position occurs in this department, known as the Engineer of Track Elevation, at a salary of \$4,200 per year. The duties of this position include the checking and approving of all plans for railroad grade separation work, including bridges, viaducts, retaining walls and the like.

Department of Civil Service.—Several very interesting technical positions occur in the Efficiency Division of the Civil Service Commission. These positions are grouped in the Technical Section of the division, which section is in charge of an Expert on System and Organization, at a salary of \$3,000 per year. The working force includes Examiners of Efficiency (technical), who are paid salaries ranging from \$1,920 to \$2,400 per year. This section makes studies of all branches of the city service for the purpose of suggesting improvements and means of economizing. These include shop studies, studies of street cleaning and garbage disposal methods, and investigations of all the activities carried on by the municipality. In addition, much graphic statistical work is handled, which is well illustrated by the organization charts reproduced in this article from a report made by this staff.

Building Department.—In the Building Department the positions of interest are those of the Architectural Engineers. There are four of these positions, paying from \$1,920 to \$2,400 per year. The duties of these positions are to check all plans for Buildings which are submitted to the Building Department, according to law, for its approval. The great diversity of work involved and the extensive variety of structures, the plans for which are passed upon by these men, make their positions of unusual worth.

Rules and Administration in Chicago Civil Service.

The foregoing description serves to call attention to the methods of carrying on engineering work in the municipal departments of Chicago. However, the advantages to be gained by entering the service cannot well be appreciated without an understanding of the manner and method of gaining promotion and the system in use for rewarding the conscientious efforts and continuous industry of individual municipal employes. As heretofore mentioned, the Civil Service Commission has placed all

positions in definitely determined classes, according to the nature of their duties, and has further established grades within each class which serve to rank each position according to its importance. For example, Class "B," comprising all positions in the Engineering Service, is divided into five grades. The highest grade includes the position of City Engineer, Engineer Board of Local Improvements, and other positions. The lowest grade, called Grade I, includes positions of Rodman and Assistant Draftsman, which positions occur to the number of forty-nine and twenty-six, respectively, in the various departments of the service. The salaries of the positions in Grade I, as specified in the Rules of the Civil Service Commission, may range from \$1,080 to \$1,320 per year. Those of positions in the highest grade range from \$4,020 to \$8,000 per year. A person who passes an examination and obtains a position in Grade I of Class "B," must start at the lowest salary for the grade, namely \$1,080 per year. He may be transferred to a similar position in another department, or in the same department, provided his new position is also classified in Grade I of Class "B." After he has been in the service for one year his pay may be increased to \$1,200 per year, and after two years of service to \$1,320 per year. His pay cannot be increased beyond this latter figure until after he has been promoted through examination. Neither can the employe be transferred to another position in a higher grade until he has shown his fitness by promotion examination, in competition with other employes in the same grade.

For the purpose of rewarding individual employes of exceptional merit, the civil service rules provide that each municipal employe shall be given a mark for efficiency by his superior officer at the end of each month. This mark is reported to the Civil Service Commission and is kept on record in its office. The markings range from 75 for average, to 100 for perfect, efficiency. It is not possible to attain the latter degree of perfection, however, and no city employe has ever received a mark of 100. The markings are based on the quality of work of the employe, with demerits subtracted, when deserved, for disciplinary reasons or delinquencies in attendance. No employe may be marked above 85 for quality of work except in case of unusual merit, nor below 75 except in case of flagrant delinquency.

The efficiency markings of employes are taken into account in cases of salary increases, desirable transfers or other special privileges. They prove of greatest importance, however, when the employe seeks promotion. All promotion examinations include a subject "Efficiency." The marking in this subject is determined by averaging the monthly efficiency markings of the candidate, as reported to the Commission by his superior officer, for the six months preceding the examination. No employe may take a promotion examination for a position in any grade, unless he has served for at least six months in a position in the next lower grade. Each candidate in promotion examinations is also given credit for his years of service by a marking in a subject called "Seniority." This marking is determined by adding from one-half to three points for each year served to a minimum mark of 75. The weight of the subject "Efficiency" is two and the weight of the subject "Seniority" is one in promotion examinations in the Engineering Service, out of a total weight of ten for all the subjects in the examination. The other subjects are "Duties," weighing four; "Mathematics," weighing two, and "Report" on an assumed state of facts, weighing one. The average attained in each of these subjects is multiplied by its weight and the products added. The sum of the products, divided by the total of weights, which is ten, gives the candidate's final average and determines his standing on the eligible lists.

In original entrance examinations the subjects of examination are: "Special Subject," which relates strictly to the particular duties of the position and corresponds to the subject "Duties" in promotion examinations, weighing five; "Mathematics," weighing two; "Experience," which includes age, educational training, and practical experience, weighing two, and "Report," weighing one. The final average is calculated as in promotion examinations.

Service of the State of Illinois.

Nearly all the employes of the State of Illinois were placed under civil service by an act of the State Legislature which took effect July 1, 1911. The State Civil Service Commission has its offices in the capital at Springfield, but maintains a branch in Chicago. The rules on classification of positions, efficiency markings, promotion and transfer are practically identical with those of the Chicago Civil Service Commission, which were above described.

While there are not a great many positions in the state service whose duties are of a technical nature, the following are included in the classified civil service, and may prove of interest:

In the State Highway Commission, one State Engineer at \$4,000 per year, one Bridge Engineer at \$2,400 per year, one Road Engineer at \$2,200 per year, one Assistant Engineer at \$2,000, one at \$1,800 and one at \$1,500 per year; four Junior Engineers at \$1,200, two at \$1,080, two at \$1,020, and two at \$960 per year, and one Testing Engineer at \$1,200 per year. These forces are engaged in laying out and supervising the construction of roads and bridges, as well as consulting with local authorities on any related engineering questions.

In the State Mining Board, twelve Mine Inspectors, at \$1,800 per year each, whose duties are sufficiently described by their titles, and who must be thoroughly familiar with conditions having a bearing on mine safety.

In the Railroad and Warehouse Commission, an Engineer, at \$5,000 per year, one Assistant Engineer at \$2,000 and one Safety Appliance Inspector at \$1,500 per year. The duties of these positions relate particularly to appraisal and valuation work, as well as to the safeguarding of the public in railroad operation.

In the Illinois Rivers and Lakes Commission, one Engineer at \$3,600 per year, one Junior Engineer at \$1,080 per year and one Hydrographic Aide at \$1,200 per year.

Service of Park Districts in Chicago.

An act of the State Legislature placing all the employes of the South Park, West Park and Lincoln Park districts under civil service became effective on July 1, 1911. The technical positions in these services are necessarily few in number. In the South Park District the following are worthy of interest:

The most important position is that of Chief Engineer, who is at the head of the Engineering and Construction Division, at a salary of \$4,200 per year, and whose position is under civil service. The Chief Engineer is in charge of all office and field forces assigned to improvement and construction work, including paving, sidewalk, drainage and sewerage construction, as well as bridges, walls, park buildings, piers, breakwaters and docks. The office work is in charge of a Chief Draftsman, who receives \$1,500 per year and who supervises the work of four Draftsmen paid from \$1,140 to \$1,380 per year, and one Junior Draftsman at

\$840 per year. The field work is in charge of Assistant Engineers, who are paid from \$1,500 to \$1,800 per year and who are assisted by six Instrument Men, paid \$1,020 to \$1,380 per year; three to five Rodmen, paid \$840 to \$960 per year; one Chainman at \$720 per year, and three Construction Inspectors, paid from \$900 to \$1,200 per year.

The Mechanical and Electrical Division is in charge of the Mechanical and Electrical Engineer, who receives \$3,600 per year. This division includes the machine shops for the repair of park automobiles, steam rollers and other equipment, the operation and maintenance of the power house in Washington Park, and the operation and maintenance of all the electric lighting and power equipment. The Assistant Mechanical and Electrical Engineer, who receives \$1,500 per year, renders general assistance to the head of this division.

Service of the West Chicago Park Commissioners.

In the West Park System all positions are under civil service with the exception of three. None of these latter are technical positions. All the engineering and construction work, as well as the operation of the electrical and mechanical equipment, is under the direction of the Chief Engineer, whose position is under civil service. The present incumbent, who also holds the position of Superintendent, receives a salary of \$4,800 per year. The field engineering work, including surveying, estimating and inspection of contract work, is in charge of an Assistant Engineer, who receives \$1,800 per year, while the office work, including drafting, designing and platting, is in charge of another Assistant Engineer at \$2,100 per year. The office force is completed by two Draftsmen at \$1,500 per year each, while the field engineering forces include an Instrumentman at \$1,500 per year, from four to six Construction Inspectors at \$1,080 per year and two Rodmen at \$720 per year.

The main heating plant and power house in Garfield Park are in charge of the Chief Heating Engineer, who also supervises the operation of the minor heating plants throughout the system. The Chief Heating Engineer receives \$2,000 per year and reports directly to the Chief Engineer. All road paving, both repair and new construction, is done under the direction of the Road Construction Superintendent, who reports directly to the Chief Engineer, and who receives \$2,100 per year. The testing

and analysis of paving materials is done by an Asphalt Chemist, who receives \$1,200 per year for part time service.

The Federal Service.

The federal service constitutes an organization so complicated and scattered that space will not allow of giving more than a few meager details regarding the possibilities it offers to the technical man. Before mentioning any of the positions it should be stated that the federal civil service laws do not provide for employes' efficiency records and for promotion systems, such as are in force in the local municipalities. Transfers are not restricted to so great an extent, and many vacancies are filled by non-competitive examinations. A strong movement is on foot for the elimination of these features, however, and that they will eventually be done away with is assured.

The United States Civil Service Commission holds examinations semi-annually at various large cities throughout the country, for the purpose of securing eligibles for vacancies in any state in the Union, in Panama, or in the Philippine Islands. Detailed information may best be obtained by addressing the Commission at Washington, D. C. A few of the available positions are as follows:

Assistant Engineer, Reclamation Service, which may include service in any part of the West, and assignment on the construction of dams, railways, bridges or retaining walls. The salary is variable, but is never less than \$1,500 per year.

Junior Engineer, Reclamation Service, which is similar to and subordinate to that above described. Salary from \$960 to \$1,500 per year.

Junior Engineer, Bureau of Mines and Engineer Department at Large, including Civil, Electrical, Mechanical and Mining Engineering work. Salary from \$960 per year up.

Draftsman, Architectural, Engineering, Mechanical, and Heating and Ventilating, for various branches of the service, and at salaries ranging from \$900 to \$2,400 per year.

Assistant Examiner, Patent Office, which proves a very desirable position for engineering graduates of limited experience, and pays \$1,500 per year. This position offers employment at Washington only, and involves the investigation of plans and claims for patent applications.

THE STEAM SHOVEL

BY E. R. WEBER.*

Since the day that man began to develop away from the original purely animal state he has been more or less actively engaged with the task of removing earth from one place and depositing it in another. The methods of removing the material have been very much the same for ages and even today much earth and rock is excavated by the familiar emigrant with pick and shovel.

The rapidly accelerating development of our country after the close of the Civil War was in a large degree due to the rapid development and extension of important waterways and railways. These types of public highways require the removal of tremendous amounts of earth and rock, and the men engaged in this work soon began to demand improvements on the man with the spade and the team and scoop.

The first steam shovel did not suddenly appear in the excavating field like a brilliant shooting star in the sky; neither was it the result of the spontaneous conception of one man. It was purely the result of a demand—yes, almost a necessity—for a more efficient means of moving earth and rock, and in the early days it developed mainly by field trial and experience.

As far as the writer has been able to learn from old timers, the Adam of Steam Shovels was built by the Pound Manufacturing Company of Lockport, N. Y., in the year 1870. This machine was crude, but from this beginning the modern machine has grown, mainly due to increasing demands for greater power, capacity and efficiency.

The steam shovel as it stands today is nothing more than a very much enlarged edition of a man with a shovel. The shovel has been changed to a big scoop called a dipper and the man is represented by the rest of the machine, which as nearly as possible goes through the motions of a man behind a shovel. You will

*Class of 1903. Division Engineer for Shovels, The Bucyrus Company, South Milwaukee, Wis.

see that though the capacity of this steel digging man has been largely increased it has nevertheless been impossible to improve upon the natural motions through which man goes when he bends his back to the task of moving earth.

The steam shovel primarily consists of a platform mounted on some means of transportation. On this platform are mounted a boiler, a hoisting engine and drum, a revolving boom at the front and machinery for swinging this boom from side to side through an angle of about 180 degrees.

The boom is usually slotted, in which slot slides a handle, and at the end of the handle is fastened the dipper. The dipper handle is shoved in and out by means of an engine mounted on the boom which drives it through pinions and racks.

The hoisting chain passes over a series of sheaves which keep it in the axis of rotation of the boom and it then runs out to the point of the boom. At the point of the boom are also mounted sheaves, and after passing over these the chain connects to the dipper direct or by means of a single sheave block.

The cycle of a steam shovel consists of lowering the dipper with a simultaneous pulling in or pushing out of the handle until the position is reached from which it is intended to dig out the bank. It is then hoisted through the bank and the depth of the bite taken being regulated by the boom engine. As soon as the dipper is clear of the bank the boom is swung over the car or wagon and the load dumped by unlatching the door. The boom is then swung back and the previous cycles are repeated.

The early shovels of necessity were small, not weighing much over 12 tons, having a small vertical boiler, a single cylinder engine which drove the hoisting and swinging machinery, and the dipper was run out by gravity as it was lowered. It was held at a fixed digging radius by means of a brake applied to the pinion or shipper shaft.

The single hoisting engine quickly developed into a double engine as dead centers were very annoying and the thrusting out of the dipper was made more positive by means of running the hoisting chain over a pocket sheave which through a clutch and gears drove the shipper shaft.

Two engines, one for hoisting and one for swinging, soon replaced the single main engine, and the chain drive of the shipper shaft was supplanted by a third engine mounted on the boom.



Bucyrus 95C Steam Shovel Excavating Iron Ore at One of the Mines of the Oliver Iron Mining Company.

The boilers in the meantime grew larger and better in quality, and it was not long before the locomotive type of boiler supplanted all others and it is today the only boiler used on steam shovels, except in the case of the very small shovels, where space makes it necessary to use the vertical boiler.

As the shovel gradually developed its sphere of usefulness also increased and with this a corresponding adaptation to its new



Atlantic Class 80 Steam Shovel Loading Blasted Rock at the Keokuk, Ia., Dam.

uses. So we have today shovels of different sizes and types used for different purposes.

The steam shovel practically originated on railroad work and it is natural that it developed along the lines required by this work. It was at first almost exclusively mounted on trucks and made so it could be readily hauled about like regular railroad equipment.

The shovel remained small, as the rest of the railroad equipment was small, and its capacity was limited by its size as well as by the ability of contractors and railroads to handle the material excavated.

Fifteen years ago a 45-ton machine was considered a good contractor's size. This machine handled a $1\frac{1}{2}$ -yard to $1\frac{3}{4}$ -yard dipper and could develop a pull at the dipper of about 45,000 pounds and could dig through ordinary loam, uncemented gravel, and could handle well blasted rock. Gradually, as railroad equipment grew larger and railroads began to cut down grades and to straighten out their lines, the cutting and filling required heavier and larger apparatus for digging and transporting the material.



Bucyrus 14B Revolving Steam Shovel Loading Sand; Owned by the O'Brien Construction Company.

The steam shovel therefore grew in size, and at various times the 55-, 60-, 65- and 70-ton shovels became standard contractor's machines, and at present the 85-ton machine is gradually becoming the standard railroad contractor's machine.

During the time that the light shovel was being developed on railroad work, another field opened up which resulted in the rapid development of the larger machines.

The great body of iron ore lying close to the surface of Northern Minnesota presented a field for developing new methods in

mining. Underground workings are always expensive and as this ore was close to the surface it was natural to scrape the overburden off and take the ore out in open workings. Early in the development of this field the small steam shovel of the railroad contractor was used for stripping the ore and for loading it into cars. The ore had to be blasted in most cases, and the desire to reduce the cost of blasting and increasing the output acted as an incentive for the development of the larger machine.

The steam shovel in this field received the acid test and shovel builders were kept busy strengthening and designing to keep up with the requirements. Gradually the 85-ton, 90-ton and 100-ton



Bucyrus 70C Electric Shovel Loading Rock at Quarry; Owned by the Granite Quarries Company, Vancouver, B. C.

machines developed, and when the United States government undertook to dig the Panama Canal there was at hand an already well developed excavator which had been tried and tested and could dig almost solid rock.

When the government came into the market for its equipment the builders took great pride in designing machines which embodied all of the good features known to them, due to their previous experience. As a result, the shovels at the Canal have made it possible to break all records and estimates, and it is largely due to them that the work at the Canal has been such a wonderful success. They were made in three sizes, 45-ton, 70-ton and 95-ton machines. The 45-ton and 70-ton machines were

used for easier work and in places not very accessible. The 95-ton machines were used for harder work and in more accessible places.

The one limit at all times of the output of a shovel is the ability of the contractor to get cars to and from the machine, and the system of carrying away the spoil has been developed to a wonderful degree at Panama. Panama is practically the only place, excepting large mining and quarry plants, where shovels are worked to their full capacity, and here the 70-ton machines are loading from 50,000 to 65,000 yards of blasted rock per month of twenty-seven 8-hour days. The 95-ton machines have excavated and loaded as high as 72,000 yards of blasted rock in the same period of working time.



Bucyrus 40R Steam Shovel; Owned by F. H. Clement & Co.

The great development of the cement industry, stone quarries, brick yards and clay products industries have opened fields for shovels and they are now found in most every quarry and pit. The 110-ton and 120-ton shovels have been developed for quarry work, and in these machines we have an excavator that can dig any clay or shale and sandstone, and blasted rock presents no difficulties.

The small shovel is also receiving the shovel builder's attention and there is now in the field a small revolving type of machine

which can dig a cellar or dig up a pavement at a much reduced cost and great saving of time over the old methods. -

Again, in Southern Indiana and in Kansas, there are great fields of coal lying close to the surface, and here another type of shovel has developed. This shovel is a revolving machine which rotates on a sub-base. The coal stripping shovels weigh from 150 to 250 tons and carry a boom 60 to 100 feet long and a dipper of $2\frac{1}{2}$ to 6 yards capacity. These machines dig their own path through the overburden to the top of the coal and can dump all of the material on one side. This overburden often runs forty feet in depth, so it is not hard to realize that the range of these machines is large.

The great electrical development going on in the country has made it necessary to adapt the shovels to electrical operation, and here another great problem has presented itself. At the present time a number of successful electrical shovels have been designed and built and are working, and at the present rate of development this type of shovel will soon be at a par with its forerunner, the steam shovel.

The shovel excavating field can now be divided into a number of general classes as follows: Railroad work, tunnel work, canal excavation, railroad ditchers, sewer trenches, stripping, surface iron and copper mining, coal stripping and building excavation. All of these classes of work require special adaptation of the shovel and in some cases a radical change of type, but the fundamental principles remain very much the same.

The question of whether or not a certain type and size of machine can do a certain kind of work is determined absolutely by experience. The steam shovel engineer must therefore not only be a mechanical engineer, but he must also be acquainted with the field performance of the machines he designs so that he can develop the market for his products.

When it is remembered that a machine is asked to dig out of the earth many kinds of materials, up to solid rock at times, and it must do this with the least breakage and greatest rapidity, it is easily understood that the steam shovel has been and is an interesting problem for the mechanical engineer. In the early days shovels were built by experiment or entirely by theory, but

today we have the problem attacked by an engineer who combines theory with practice.

The design of the shovel is an intricate problem and there are so many variations that it would be impossible to proceed into this phase of the subject and the writer will not attempt its discussion here. The design of shovels and other excavating machinery requires, like any other engineering work, the proper application of theory and plenty of horse sense acquired by experience and field observation. The field is a large and interesting one and the writer has often wondered why not more promising young engineers do not enter upon this line of work.



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The affairs of the Armour Alumni Association have received added impetus each year. Possibly one of the best suggestions for livening up the interest of the graduates is that of an "Alumni Homecoming." It is safe to say that there is a large percentage of alumni, even among those living in Chicago, who have not paid their Alma Mater a visit since graduation. With this fact in mind, the officers of the Association have made arrangements

for a homecoming Saturday, May 24. There will be a Tech-Alumni baseball game and track events in the afternoon, followed by an inspection of the buildings and a supper served in the library, with after-dinner speeches. Music will be furnished by the A. I. T. musical organizations. As customary, the graduating class will be the guests of the Association. It is unnecessary to lead any Armour man to the festivities. Surely he ought to know the old route he traveled so many times.

The banquets and events given by the Association have not been of benefit to the alumni living outside of Chicago, and the officers realize that those members have not derived a great deal from their membership in the organization. These men should receive some return for paying their obligations to the Association. Accordingly plans are at present being made by the Armour Alumni Association with THE ARMOUR ENGINEER whereby each active member in good standing will receive regularly copies of this magazine without paying more than his yearly dues to the Association. An alumni department, conducted by one of the alumni members, will serve to keep the graduates in touch with the activities of the organization and its members. Such an arrangement would undoubtedly prove of benefit to the Association, to the graduates and to THE ARMOUR ENGINEER, and it is hoped the plans will be completed before the next school year.

The following sketch, written by Prof. L. C. Monin, dean of Armour Institute of Technology, is entitled "Ethics of the Engineering Profession,"* and was first published in *The Fulcrum*, the monthly publication of the students of Armour Institute of Technology. As it is of especial interest to engineers in practice THE ARMOUR ENGINEER takes pleasure in submitting it to the alumni:

*"Professional Ideals of the Twentieth Century," by President Hadley of Yale. *Engineering Record*, April 20, 1907, Vol. 55, No. 16, p. 486.

"Engineering Honor," by Schuyler Skaats Wheeler.

Proceedings of the American Institute of Electrical Engineers, Vol. XXV., 1906, p. 241.

"A Code of Engineering Ethics." Drawn up by a committee of the American Institute of Electrical Engineers.

Engineering Magazine, Vol. 33, 1907, p. 799.

"The Relation of Civil Engineering to Other Branches of Science," by Alexander Low Waddell.

Congress of Arts and Science, Medicine and Technology, Vol. V., 1906, p. 555.

The present time considers engineering as a profession, like medicine, the ministry, law, architecture, and teaching. The several branches of engineering form a special subject which is now so systematized and formulated that long years of special training and diligent application to the particular problems involved are necessary. The interests of the public in matters of engineering are, therefore, in the hands of specialists called engineers, and the relations between them and their clients are now looked upon as being in no way different from the relations between physicians or lawyers and their respective clients. The responsibilities of the professional man towards the public employing him are very great, although they are not always recognized by the specialists. When anybody is in charge of the interests, whether legal, financial, spiritual, or otherwise, of anybody else, his work is of an altruistic character. Therefore, it demands a certain *standard of professional conduct* and of moral integrity. An engineer, for the reason that he has specific knowledge, skill, and training in taking care of certain interests of his clients, is under moral and professional obligations. A codification of these obligations constitutes what is known as the "ethics of the engineering profession."

Any student entering upon the career of an engineer should be clearly conscious of the fact that two things are demanded of him: First, the *technical standard* (his knowledge and grasp of the subject); second, the *ethical standard* (his sense and understanding of his professional obligations).

According to the usages so far adopted, the *moral duties* of the practicing engineer may be classified as follows:

(1) The engineer's duty to his *client*.

This is the most important obligation. The best thought and work of the engineer belongs to the client. The latter deserves most careful consideration in matters of confidence. Many consulting engineers are affiliated with manufacturing concerns interested in the sale of a particular apparatus. The manufacturers may recommend the engineer to the client and the engineer may recommend the apparatus, or vice versa. In such relationships it is very essential that the engineer be honest and absolutely truthful in regard to the value and usefulness of the apparatus.

Drawings and data collected for a client in the course of engineering work are usually regarded the property of the engineer.

However, as such records are often an exact statement of the affairs of the client, the engineer must be very careful in the preservation of them. If he should misuse them the consequences might be very grave. In other professions the layman employs aid simply for experience and advice, but hardly ever is there any occasion to have a record made of preliminary or final results. In engineering work, however, this is absolutely necessary. Thus, a great moral responsibility devolves upon the engineer; namely, not to furnish to strangers, through carelessness or dishonesty, designs, drawings, or patents which are the property of others and happen to be in the engineer's possession.

(2) The engineer's duty to the *public*.

It has been said that his duty in this regard is largely educational. When a man or a community trusts the engineer and his judgment, he is bound to respect this trust, or he will lose his standing in the community. If called upon to explain matters in council or in private meetings of business concerns, he must explain the real facts and the real situation, the real need, possibilities, and cost of the problem involved. The more his clients are able to understand the real facts in the case, the more will they appreciate his difficulties and merits in the carrying out of the undertaking. Any engineer is shirking his duty who does not to the best of his ability set the client aright who comes for advice and guidance. The public is always entitled to the simplest and truest statements of the expert's knowledge and experience.

(3) The engineer's duty to the *members of his profession*.

Having entered upon a profession, any member thereof is in duty bound to support its interests to the best of his ability. It has been well said that the best estimate of any man's service and character is always made by the brethren of his own craft. Therefore he must be loyal to them, helpful and courteous. Whenever possible, he should become a member of the engineering society which embodies the technical and ethical ideals of his calling. It devolves upon him to contribute to the support of such a society, for in its turn it will dignify his standing in the community and in many ways be helpful to him.

(4) The engineer's duty to *himself*.

This duty is no other than that of all men; namely, to be loyal to their better selves. When the student has once acquired a pur-

pose in life and sees the general direction in which his character and his ability will find their best development, let him remain loyal to the ideal thus set before him. Above all, let no professional man forget that his salvation lies in keeping up with his profession, not only in learning, circumspection and skill, but also in the conception and formulating of high ideals of professional conduct. If engineering is to be a profession in the true meaning of the word the engineer must be more than a builder, mechanic, or electrician. He must regard himself not merely as an employee but as an employer. Even if he has no one else under his charge but himself, he is the employer of his own resources, and as such a one he has as many responsibilities and duties devolving upon himself as if he were a superintendent intrusted with the command of hundreds of men. "Love the art which thou hast learned and be content with it" is the fine advice given to the world by the Roman emperor Antonius. Once the title and the work of an engineer are assumed, the responsibilities and duties of high moral integrity and of a high ethical standard are immediately implied.

It is interesting to note how different engineering societies have already worked out their code of ethics. (See *Proceedings of the American Institute of Electrical Engineers*, Vol. 25, 1906, pp. 248-265.)

The ministry of each denomination has its code of ethics. The principles of medical ethics of the American Medical Society were formulated and adopted in 1903. Architects are guided by the code of ethics of the Boston Society of Architects. For the profession of law, a series of lectures delivered before the law class of the University of Pennsylvania in 1854 by Judge George Charswood has become the standard. While it is not a formulated code, it serves as a guide.

The student of engineering should clearly understand that *engineering is public service*, and the latter involves not only the *work*, but also the *character* of the man. General training in cultural and ethical work should not be overlooked, for when an engineer rises in a community, it is due chiefly to the integrity of his character, the altruistic point of view which he is able to take of his profession, and to the high ideals of personal conduct making him the man of the right stamp. *Sincerity, simplicity, and*

service are the three watchwords which should be written upon the heart of every young man entering upon this very useful and very influential career.

There are many considerations the college graduate in search of a position must consider. A man applying for a position may indicate, to a certain extent, the kind of work that he can do by his appearance and personality. By this it is not meant that he should have expensive clothes, for it is neatness that is essential, inasmuch as it brings before the employer's mind a picture of the neat and well-constructed reports which he will expect at such times as he may demand. It is not the person who has the exaggerated tale of what he has done and can do that secures a desirable position, but it is the man making his statements in an honest, frank and concise manner who is more apt to be successful. When an applicant complains that he has been held down by his last employer and not given a fair chance he merely gives a verbal statement from his past employer to the effect that he is not a desirable man, because the truth is, as a general thing, that his foreman could not hold him up.

The head of any department always expects his men to be willing to do any work that may be assigned to them, and in the procedure of their tasks it is the employe's duty to take care of the details and not trouble the manager with them. However, it is expected that the employe will come forward with any suggestions which he has thought over carefully beforehand. It must be understood that it does not make any difference how mean and trifling the work may seem at times, because that is the big thing and the only thing for the employe at that time. Business will not mix with anything but business. Most any one knows that education will broaden a narrow mind, but there is no cure for the big head. The manager of any department, therefore, knows that the mean and trifling jobs will not spoil a good man. In general, it may be said that accuracy and good judgment, rather than speed, are expected; consequently the employer is going to be very careful when it comes to choosing the men for his department.

—R. W. W.

Mail addressed to the following alumni has been returned unclaimed to the Corresponding Secretary of the Armour Alumni

Association. Any one knowing the correct address of any of these men will confer a favor by notifying Mr. Daniel Roesch, Corresponding Secretary, Thirty-third street and Armour avenue, Chicago.

1897.
Chapman, Paul R.

1900.
Campbell, Mrs. M. W.
Martin, Robert C.

1901.
Eustice, Charles E.

1902.
Harwood, E. T.
Persons, Victor S.

1903.
Rawson, H. B.

1904.
Knapp, Morris J.

1905.
Jones, Clarence I.
MacMillan, Arthur W.

1906.
Edson, Norman L.
Meyer, Eugene D.
Morrison, Ralph D.
Pierce, Francis T.
Schumacher, Joseph N.

1907.
Sanders, Walter J.
Sigwalt, Elmer.
Tompkins, George D.

1908.
Holmboe, Ralph.
Matthei, Henry B.
Meyer, Grover J.
Lawrence, Victor E.
Thomson, Frank L.

1909.
Ecklund, C. A.
Evans, Robert T.
Megahy, James E.

1910.
Clarkson, William, Jr.
Cole, Victor E.
Zeisler, Louis T.

1911.
Doering, Robert C.
Hay, Robert.
Hynes, Percy R.

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

The first meeting of the second semester was held February 6, and Mr. O. C. K. Hutchinson, of the class of 1914, gave a talk on "Gas Engine Ignition Systems." The common systems for ignition were well illustrated and explained.

On February 20 Mr. George M. Ambrust, of the Commonwealth-Edison Company, delivered a lecture on "The Distribution System of a Large Central Station." The lecturer illustrated his points with a large number of lantern slides and showed the general layout of the company's distribution system. The meeting was well attended, both by undergraduates and alumni, and much benefit was derived by them.

On April 20 Mr. A. C. Lill, '13, gave a paper on "The Hydro-electric Development at Keokuk, Iowa." Mr. Lill had paid a visit to this power plant earlier in the year, and as a result gave a very able description and pointed out some of the distinctive features of this great power development.

The annual spring banquet and election of officers was held at the Boston Oyster House, April 26. As usual, this event was well attended. The faculty members and most of the students present responded to calls for short speeches, many of which were very untechnical but helped to make the gathering an enjoyable one. The officers for the ensuing year will be: Prof. E. H. Freeman, secretary; E. L. Nelson, chairman; T. C. Bolton, recording secretary, and A. F. Schoembs, treasurer. The large number of spirited Junior Electricals will be a factor toward making the affairs of the Branch fairly hum next year, and the officers have the opportunity of making a fine showing.

—R. L. Walsh.

ARMOUR INSTITUTE OF TECHNOLOGY BRANCH OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

The first meeting of the year 1913 was held on February 15. The speaker of the evening was Mr. C. W. Naylor, chief engineer of a large Chicago dry goods concern. His company uses central station current and, being an institution catering to the general public, different conditions are there met with than are found in the ordinary commercial plant. Being of a humorous turn of mind, Mr. Naylor held the attention of his audience far beyond the usual time of adjournment.

On January 18 the society held its semi-annual banquet at the Boston Oyster House. Here, contrary to the usual routine,

speeches were dispensed with, for the happy spirit prevailing did not seem to call for any. Everybody had a jolly good time and all carried away with them the feeling that this occasion was one of the most enjoyable events ever given by the society.

On February 5 Mr. W. H. Green presented a paper on "The Wilsey Fuel Economy Gauge." This instrument, the invention of a former student, indicates and records the relative efficiency of a boiler installation. Although no figures are claimed for it, nevertheless it is an aid toward consistent operation of this end of a plant. One of these instruments is applied to a boiler at the Institute.

The next regular meeting was held March 6. After the business of the society had been disposed of, the remainder of the evening was devoted to the lecture of Mr. T. A. Peebles, whose subject was "Furnace Design." Illustrating different types of furnaces by means of numerous lantern slides, the speaker pointed out the various characteristics. Owing to his experience in this line of work, Mr. Peebles was fully able to describe furnaces which are particularly adapted to high rates of combustion.

The society has been extremely fortunate during the past year in obtaining speakers for their meetings. Since these are men of the business world the students are given an opportunity to look at phases of their branch of engineering from the commercial point of view.

The regular Chicago members of the A. S. M. E. have formed a branch society and invitations to their meetings have been extended to the members of the local student branch. By attending these meetings the undergraduates are brought in touch personally with men well up in the engineering profession, and this is of advantage to them in many ways.

—H. R. Kuehn.

THE CIVIL ENGINEERING SOCIETY.

The Civil Engineering Society held a smoker in the Y. M. C. A. rooms in Chapin Hall, February 4, in place of a regular meeting. The "smokes and eats" were enjoyed by a faculty and a great number of alumni, as well as by the student members. Classes as far back as 1909 were well represented and many interesting experiences that fall to the lot of the young engineer were related by the graduates to the prospectives present.

On February 25 the society held its annual election. In place of a regular speaker, talks by the students were given. Mr. O. C. Badger spoke on "Practical Points Relating to Steel Car Construction Work." Mr. A. C. Cramer explained several interesting methods employed in the design of a "Reinforced Concrete Railroad Structure." Mr. J. T. Lucas presented a short article on "The South Park Water Supply Tunnel." Mr. C. A. Dean gave

a short resume of his recent inspection trip to the Mississippi Power Company's development at Keokuk, Iowa.

On March 25 Mr. C. O. Johnson, '06, of the Bridge Building Department, City of Chicago, spoke on "The Indiana Street Bridge." His talk was very interesting, the hydraulic men enjoying it as well as the structural men.

On April 15 Mr. G. H. Wilsey, '08, addressed the society on "The Design of a Steel Building." The talk was informal, and with the use of blueprints proved very helpful to the seniors, as they are at present designing a steel building.

The annual banquet of the society was held April 22 at the Great Northern Hotel, and was well attended. In the course of the banquet Mr. Amsbury, well known to Armour men, recited several of his original poems. After-dinner speeches were made by Dean Raymond, Professors Phillips, Wells, Armstrong, Dean, Penn and McMullin.

The society has had a very prosperous year, and the members have derived a great deal of benefit from the meetings.

—Henry F. Israel.

THE SENIOR CHEMICAL SOCIETY.

The society held its annual alumni banquet January 15 in the Crystal Room of the Hotel Sherman. Twenty-five of the alumni and undergraduates attended. Mr. H. Sieck, '11, gave a very interesting talk on "Cocoanut Oil," and Mr. R. B. Harper, '05, spoke on "Success," illustrating his remarks with numerous examples. Mr. C. C. Heritage, '14, favored the assembly with a solo. Several of the alumni and the "Chief" also gave informal talks.

The next dinner was held March 5 at the City Club. Mr. D. K. French, secretary of the Chicago Section, American Chemical Society, spoke on "Commercial Methods of Water Analysis." The speaker illustrated with typical analyses the systematized methods by which rapidity is secured in commercial work. The meeting was well attended.

Another dinner will be held late in May and it is hoped this event will prove as successful as preceding ones.

—R. S. Ziehn.

ALUMNI NOTES.

1897.

B. H. Glover is now assistant engineer with the Underwriters' Laboratories, Chicago.

F. C. Johnson is the director of the Industrial and Household Department, Florida A. & M. College, Tallahassee, Fla.

R. H. Rice has been advanced to the position of electrical engineer with the Chicago Traction Company.

W. F. Sims is now construction superintendent with the Stone & Webster Engineering Corporation, and at present is at Keokuk, Iowa.

1899.

C. P. Schroeder is engineer with M. C. Schwab, consulting engineer, Mallers Building, Chicago.

Benedict Shubart is a member of the firm of Lindrooth, Shubart & Co., Denver, Colo.

1901.

J. H. Parker, who has been recorded as deceased in the "Alumni Roster" for several years, is very much alive and is with the Columbian Electric Company, St. Joseph, Mo.

F. G. Pease is assistant at the Solar Observatory, Pasadena, Cal.

1902.

M. C. Fairweather is now insurance surveyor, 1610 Park Building, Cleveland, Ohio.

R. M. Heskett is now a member of the firm of Knox, Heskett & Co., 1410 Fisher Building, Chicago.

Ivan D. Miller is with the Chicago & Northwestern Railroad, Chicago.

1903.

J. H. S. Mueller is in the contracting business, 706 West Front street, Cincinnati, Ohio.

W. S. Taussig is in the Power and Mining Department, General Electric Company, Chicago.

S. J. W. Wendt is now chief clerk with the Public Service Company, Waukegan, Ill.

1904.

F. A. Coy is assistant engineer with the G. L. Clausen Company, 139 North Clark street, Chicago.

The 1904 class is unfortunate in the loss of another member, Harry A. Hart, who passed away this spring.

E. L. Lundgren, who has been in the Philippines, is now Instructor in Mechanics, Leland Stanford University, Palo Alto, Cal.

C. C. Sampson is gas engineer with the Illinois Steel Company, Joliet, Ill. He has charge of the new gas-electric power plant of that company, to which the Senior Electricals paid an inspection visit early this spring.

1905.

W. F. Parker is sales engineer with the Electric Appliance Company, Chicago.

L. V. Stem is resident inspector of the Rock Island Lines, Pittsburgh, Pa.

1906.

Maurice Elkin is with the Elkin Manufacturing Company, 312 Willow street, Philadelphia, Pa.

Einar Enander is taking a post-graduate course at the Institute.

Philip Harrington is now Junior Engineer with the Sanitary District of Chicago.

E. F. Hiller is with the city of Chicago as examiner of efficiency.

V. A. Houghton is a salesman, with address at 174 North Market street, Chicago.

H. G. R. Quin is chemist with the F. J. Lewis Manufacturing Company, Moline, Ill.

R. E. Swearingen is now general inspector, New York Underwriters' Agency, 19 South La Salle street, Chicago.

Augustine Davis, Jr., who is president of the Ohio Welding & Manufacturing Company, Cincinnati, Ohio, was a visitor at the Institute last registration day.

1907.

Balthasar Hoffman is assistant mechanical engineer, Chicago Association of Commerce, Committee of Investigation on Smoke Abatement, Chicago.

C. U. Smith is assistant engineer of construction with the Chicago, Milwaukee & St. Paul Railroad at Clanhassen, Minn.

I. J. Turnbull is superintendent of construction, Western Steel Car & Foundry Company, Hegewisch, Ill.

1908.

E. W. Adams is now patent attorney with the Western Electric Company, New York City.

S. E. Lunak is assistant chemist, Forest Service, United States Department of Agriculture, at Wausau, Wis.

C. R. Morey is water, light and sewer commissioner, Hastings, Neb.

P. J. Pahlman is now Instructor in Manual Training, Lake High School, Chicago.

W. W. Patrick has been promoted to chief chemist, International Harvester Company, Chicago.

C. H. Teesdale is assistant engineer in the Forest Products Laboratory, Madison, Wis.

R. A. Winser is engineer in the water department of the City of Parsons, Kan.

1909.

H. C. Anderson is with the American Bridge Company, Gary, Ind.

G. G. Goheen is sales engineer, Power and Mining Department, General Electric Company, Joplin, Mo.

Carl Heim is district sales engineer for several manufacturing companies, and has offices in the Fort Dearborn Building, Chicago.

C. H. Jones has been promoted to assistant electrical engineer, Metropolitan West Side Elevated Railroad, Chicago.

E. V. McKarahan is special agent, Improved Risk Department, Home Insurance Company, Kansas City, Mo.

B. J. McAuley is efficiency engineer with the R. R. Donnelly & Sons Company, Chicago.

Ivan Peterson is in the employ of the City of Chicago as civil engineer.

H. W. Schlinz is with the Rogers Company, consulting engineers, Chicago.

A. P. Strong has been promoted to superintendent of the Ash-Handling Construction Department, Green Engineering Company, Chicago.

H. W. Youngberg is with the Mead-Morrison Manufacturing Company, Chicago.

1910.

A. A. Byers is now in the Electrical Department, Union Stockyards & Transit Company, Chicago.

William Clarkson, Jr., is now consulting engineer, Corsicana, Tex.

H. E. Moyses is with the Moyses & Dreyfuss Company, New York City. He recently became a life member of the Armour Alumni Association.

E. D. MacEwing is in the Inspection Department, Commonwealth-Edison Company, Chicago.

W. J. Neville is with J. B. Hewitt & Co., electrical contractors, Chicago.

M. A. Smith, who is Chicago district manager of the Haslett Spiral Chute Company, became a benedict last February.

F. R. Squair is assistant examiner of patents, Patent Office, Washington.

Duvall Williams is with the Pennsylvania Lines, Track Elevation Office, Chicago.

1911.

A. E. Bredlau is designing engineer, Bridge and Harbor Division, City of Chicago.

H. L. Butler is civil engineer, Chicago & Northwestern Railroad, at Pekin, Ill.

W. W. Drew is now with the Electric Appliance Company, Chicago.

R. L. Gray is assistant electrical engineer, Public Works Department, Christchurch, New Zealand.

W. O. Heitner is efficiency engineer, Chicago City Railway Company.

H. W. Jones is inspector with the Chicago, Milwaukee & St. Paul Railroad, Chicago.

A. C. Lohse is in the Power Plant Construction Department, Whitman & Barnes Company, Chicago.

F. W. Metz is with the Louisville & Nashville Railroad, Pewee Valley, Ky.

A. N. Rebori, who was Associate Professor of Architecture, is now Professor of Architectural Design, Armour Institute of Technology.

M. J. Salomon is in the Engineering Department, City of Chicago.

Ignatius Szczychi has changed his name to Ignatius Sears and is with the Concrete Steel Products Company, Chicago.

Herbert Sieck is chemist in charge, American Coconut Butter Company, Chicago.

William Sieck is assistant engineer, N. K. Fairbanks Company, Chicago.

L. A. Simons is now with the Chicago, Milwaukee & St. Paul Railroad, Chicago.

1912.

R. C. Armstrong, who was with the Public Service Company, is now with the Western Electric Company, Chicago.

O. F. Abrahamson is in the Sales Department, Commonwealth-Edison Company, Chicago.

F. C. Dierking is with the Chicago, Burlington & Quincy Railroad, Chicago.

E. V. Dewalt is architectural draftsman, with Howard Shaw, Chicago.

H. A. Drew is in the Inspection Department, Commonwealth-Edison Company, Chicago.

D. F. Holtman is in the Bridge Department, Chicago, Milwaukee & St. Paul Railroad, Chicago.

L. D. Kiley is mechanical engineer with Charles W. Hills & Son, patent attorneys, Chicago.

N. F. Kimball, who was with the Studebaker Corporation, Detroit, is now assistant engineer, Underwriters' Laboratories, Chicago.

M. F. Lawrence is with the Westinghouse Machine Company, Wilkinsburg, Pa.

W. A. Lindberg is with the Commonwealth-Edison Company, Chicago.

G. R. Meade is now with the Sanitary District of Chicago.

J. C. Michael, Jr., who started out on a trip around the world last September, had to content himself with six trips across the Atlantic, and, returning to Chicago, is now in the Inspection Department, Commonwealth-Edison Company, Chicago.

H. E. Noren is with the Public Service Company, Chicago.

E. E. Piper is Instructor of Manual Training, Bowen High School, Chicago.

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(Signed) J. D. BRADFORD

Business Manager.

Sworn to and subscribed before me this 7th day of May, 1913.

JULIA BEVERIDGE

Notary Public.

My commission expires Jan. 8, 1914.

